May-June 1961

GAS TURBINE

THE UNIVERSITY
OF TEXAS
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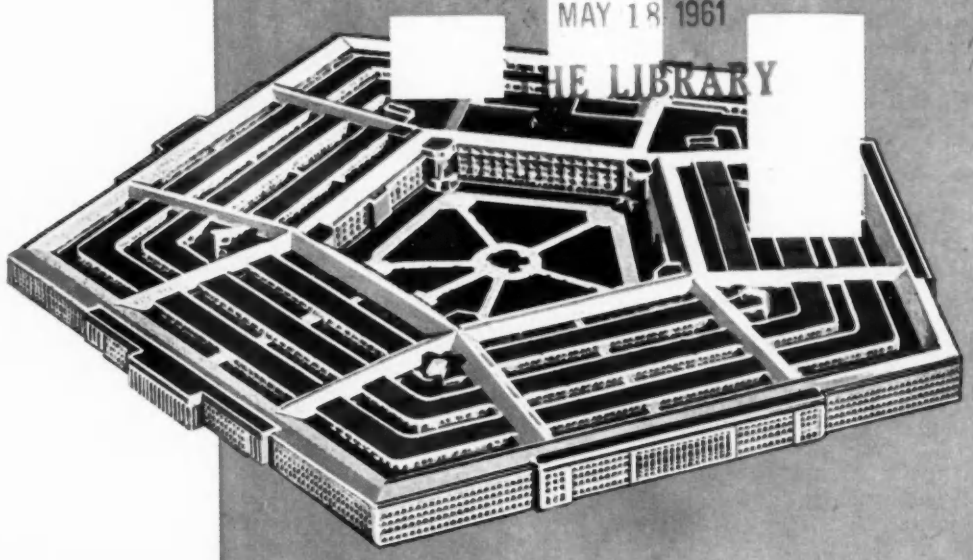


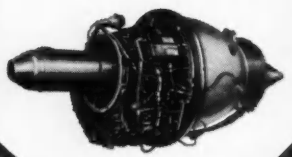
0.4 LB/HP HR!
TARGET

Army-Navy Program

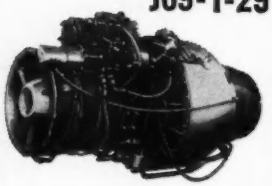
BEHIND THIS LOW-COST TURBINE POWER

—A Million-Hour Record of Service

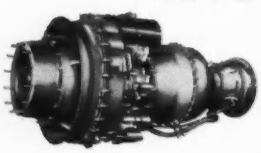
J69-T-25



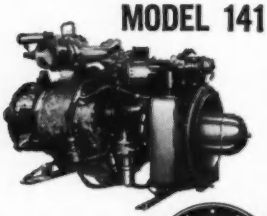
J69-T-29



T72-T-2



MODEL 141



Simplicity, operating economy, and low cost have teamed up with a brilliant performance record to make Continental turbine engines an important item in the inventory of American powerplants. The J69 alone has logged more than a million operating hours to date. Advanced models growing out of the J69 program now await industry application. They include aircraft turbojets of 1,400 and 2,400 lbs. thrust, "aft-fan" turbofan engines of 2,600 and 4,000 lbs. thrust, a target-missile turbojet of 2,550 lbs. thrust, altitude thrust augmentation devices for existing turbojets, and the J69-T-35 air pump for boundary layer control. Rounding out Continental's capability in the field of aircraft propulsion is a completely new series of turboshaft and turboprop engines, including the 500-hp, 6,000-rpm 217-5A (U. S. Navy designation T72-T-2) turboshaft, which promises to find use in a wide variety of applications.

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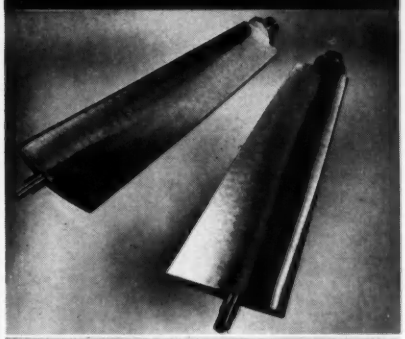

Much time, effort and cost go into developing the processes necessary to produce satisfactory sheet metal fabrications. *The Stalker process has been PROVEN—with the production of many quality blades and vanes, as well as other brazed sheet metal assemblies.* Stalker Orthobrazed stainless steel or super-alloy fabrications—such as compressor and turbine blades—are *dimensionally and thermally stable.*

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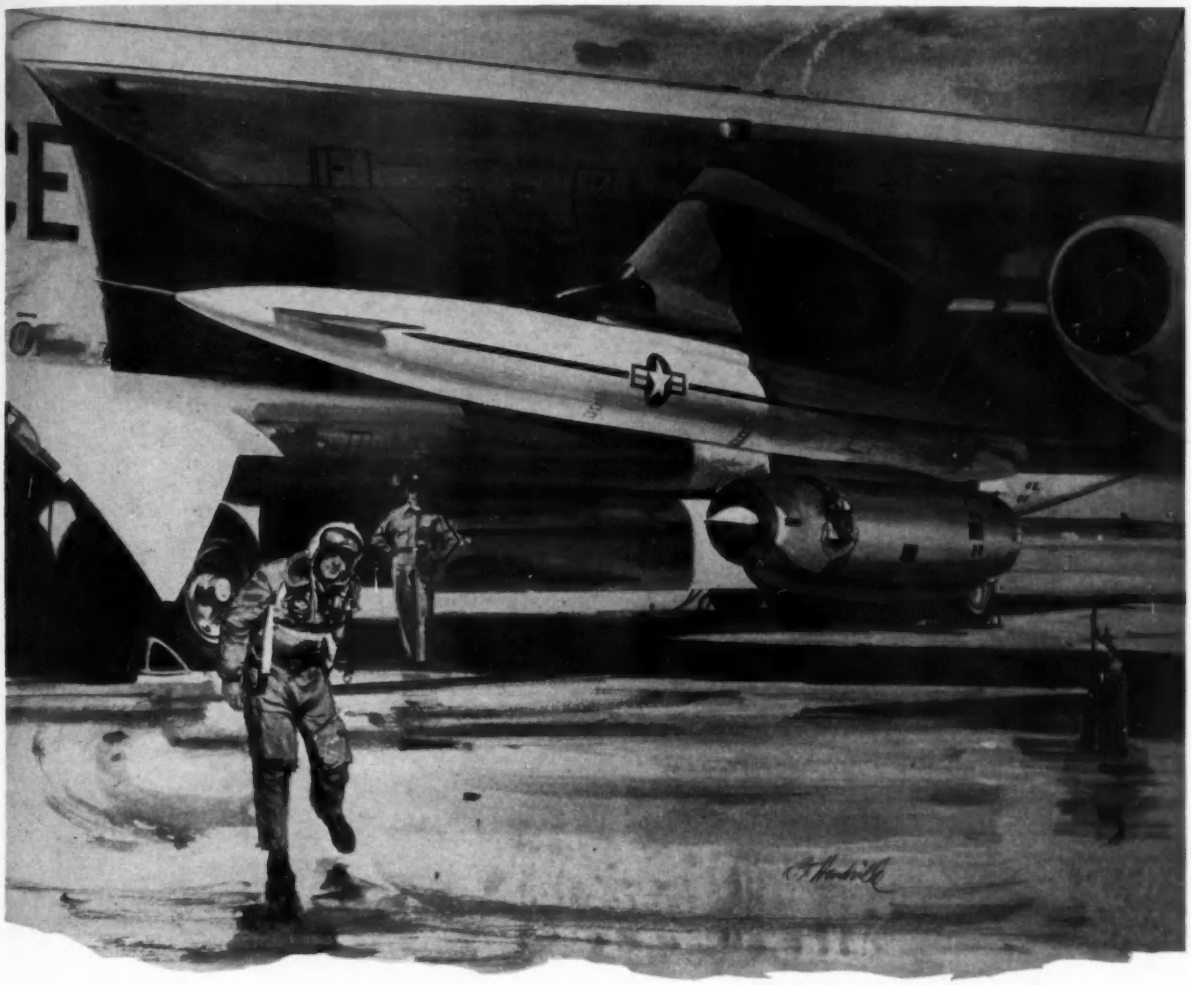

From an original painting for CECO by R. T. Handville

Contributing to the superb performance . . . of North American Aviation's Hound Dog missile is a Pratt & Whitney Aircraft J-52 turbojet equipped with *main fuel pump* engineered and precision-produced by Chandler Evans. The J-57 engines powering Boeing's B-52G "missile platform" bomber are similarly equipped.

Products, too are "known by the company they keep", and CECO is proud to be airborne with an array of important missiles as well as with many of the latest and finest military and commercial aircraft.

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Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Department 40.

CECO® SYSTEMS CONTROLS

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Union Pacific's new and mighty locomotive crests Sherman Hill, Wyoming, with a heavy load.

WORLD'S MOST POWERFUL LOCOMOTIVE SPEEDS FREIGHT ECONOMICALLY WITH BENDIX FUEL AND IGNITION SYSTEMS

This is the world's mightiest self-powered locomotive at work. On level track, it can pull 735 fully loaded freight cars—a train more than seven miles long! Its two engines—an auxiliary diesel engine and a gas-turbine power plant—depend on Bendix fuel injection and ignition systems to help keep its mighty power flowing smoothly and efficiently.

This new gas turbine-electric locomotive, built by General Electric for Union Pacific, is designed to haul freight faster and more economically. It burns less expensive "residual" fuel—a thick, viscous substance with a heavy tar content which must be heated before it will flow freely.

The Bendix ignition system fires this low-volatile fuel as efficiently as volatile gasoline is ignited in your automobile engine. The Bendix fuel injection system is used in the auxiliary diesel engine, which also furnishes power for "yard" movement of the locomotive.

General Electric has been an important builder of locomotives for more than 65 years. To be selected as the supplier of fuel injection and ignition equipment by G.E. for the mightiest locomotive they have ever built, is truly one of the finest tributes that could be paid to the all around efficiency of Bendix equipment.

It is equally impressive that whenever exceptional performance, complete dependability and operating economy are the requirements, diesel engine manufacturers in increasing numbers are turning to Bendix for their fuel injection and ignition requirements.

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THE Bendix CORPORATION

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Auxiliary Gas Turbines becoming a prime power source for industry

Helmut Schelp, chief engineer, AiResearch Manufacturing Division of Arizona, Phoenix, surrounded by typical gas turbines now in production ranging in size from 30 to 850 hp. Clockwise from the top: GTC 85-18 GTCP 105 · GTP 70-6 · GTP 30-1 · GTP 70-10 · GTU 85-2.

AiResearch Gas Turbine Engines, the most widely used power source for the starting, air conditioning, cooling and heating of jet aircraft, now are becoming a prime power source for industry.

Easier to maintain because of few moving parts, these lightweight gas turbine engines develop more horsepower per pound of weight and size than any other engine. Achieving their greatest efficiency at maximum speeds, they run on almost any fuel and start immediately in any weather.

Future prime power applications of AiResearch gas turbines for industry: earthmoving equipment; small independent generator plants; marine use; helicopters and small conventional aircraft; emergency power plants; air conditioning, heating and refrigeration; atomic energy; compressor sets and air drilling for gas gathering.

First to design and develop a successful small gas turbine engine, Garrett is the world's largest manufacturer of lightweight turbomachinery — having delivered more than 200,000 units, including 9000 gas turbines of all types ranging from 30 to 850 hp. Through its AiResearch Manufacturing Divisions, The Garrett Corporation is now offering this experience to all industry.

THE GARRETT CORPORATION

AiResearch Manufacturing Divisions

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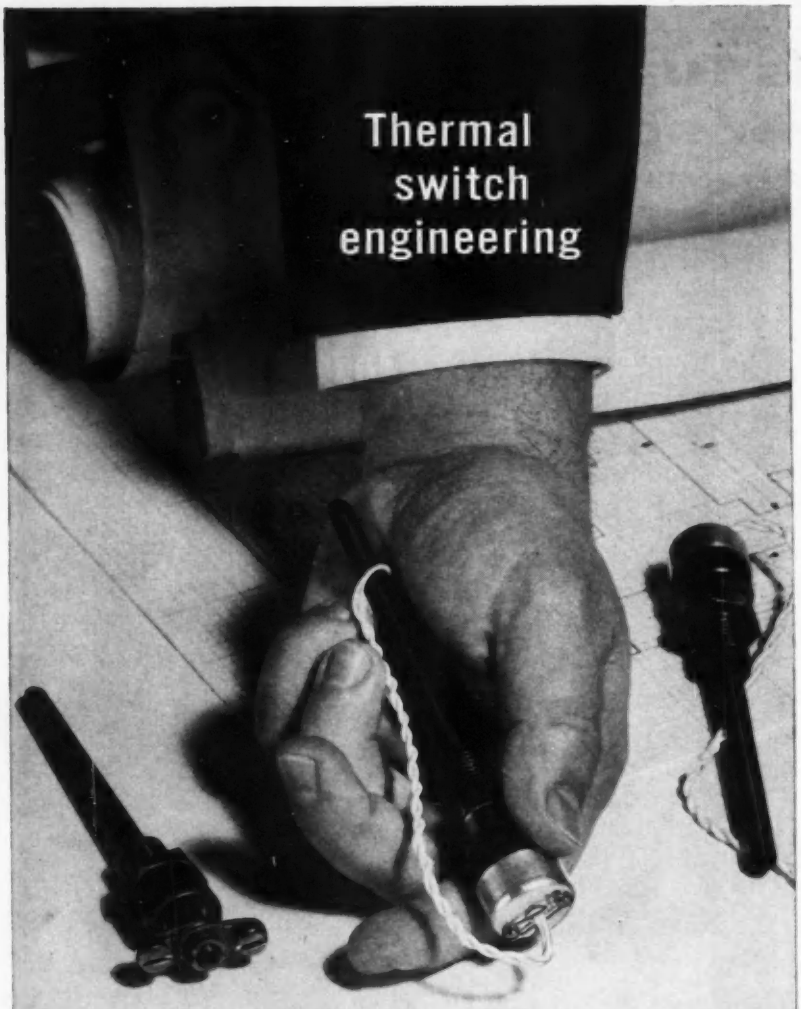

CPI R&D OFFERS A SUPER-HIGH TEMPERATURE CONTROL SWITCH WITH A CHOICE OF SEALING

Here's real thermal switch engineering! The original super-high temperature CPI thermal switch (to the left in the illustration) was environmentally sealed and performed excellently. However, the interest that it created for additional applications led to even further development. CPI research went to work and came up with a modification of the original super-high temperature switch. Now the switch is available with an internally hermetically sealed head construction, using a special ceramic seal.

This is another case story of how CPI research can help solve your thermal control problems. If you have such problems now, tell us about them.

These probe-type thermal switches can be calibrated up to 1750°F. Each can safely overshoot to 2200°F or undershoot to −100°F and both exceed standards of MIL-E-5272A. Applications include gas turbines and rocket engines.

CPI

CONTROL PRODUCTS, INC.

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SEVENTH ANNUAL

GAS TURBINE CONFERENCE and PRODUCTS SHOW

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MARCH 5-8, 1962

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ANNUAL CONFERENCE of the PROCESS INDUSTRIES DIVISION of ASME Will Meet at the Same Time and Place

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GAS TURBINE

VOLUME 2, No. 3, May-June, 1961

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Subscription Rates

	Single Copies	1 Year	2 Year
U. S.	$0.75	$3.00	$5.00
Canada	$0.75	$3.00	$5.00
Foreign	$1.50	$5.00	$9.00

Back Issues — Twice Published Rate

GAS TURBINE, published at Kutztown, Pa. by Gas Turbine Publications, Inc. Executive and Editorial Offices: 80 Lincoln Ave., Stamford, Conn. Telephone: DAvis 4-2131 Cable address: Diesel-pub, New York Volume 2, No. 3, May-June, 1961.

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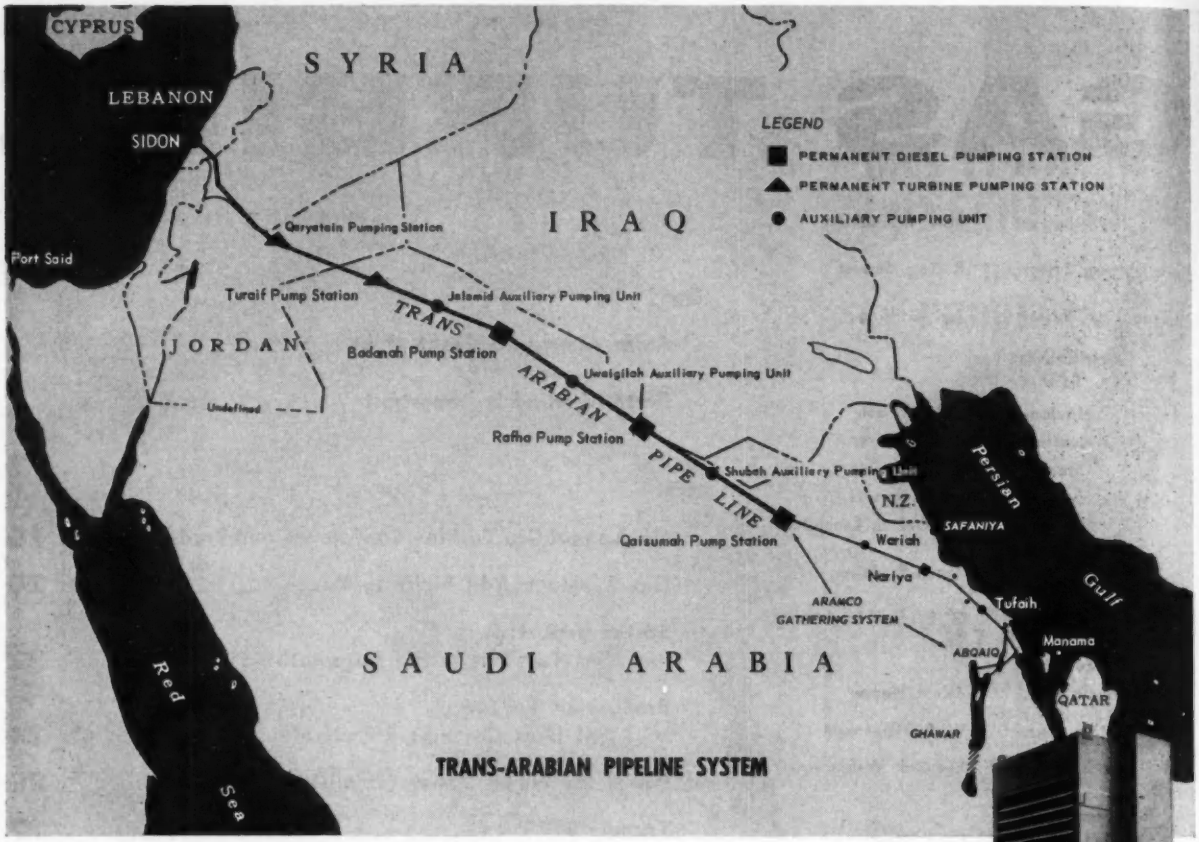

Type CMS Multi-Duty self-cleaning filter

From the Persian Gulf to the Mediterranean...

AAF cleans dust-storm air along 1000-mile desert pipeline!

Dust storms and 120° temperatures are frequent along the 1068-mile trans-Arabian pipeline system—from oil fields near the Persian Gulf to the offshore loading terminal on Lebanon's Mediterranean coast.

In both unattended portable and permanent turbine pumping units along the vast line, power equipment capable of moving 460,000 bbl. per day is protected by *clean air* from AAF's high-efficiency, self-cleaning filters. The dust-free ventilating air in the unattended portable units also carries off excessive heat and oil vapors, minimizing the risk of igniting from hot turbine surfaces.

For Arctic regions and temperate climes (as well as arid deserts), AAF designs maintenance-free filters to provide clean intake air for the safe, efficient operation of your compressors and engines. For complete information, call your nearest AAF representative, or write direct for Bulletin 150. Address: Mr. Robert Moore, American Air Filter Company, Inc., 490 Central Avenue, Louisville, Kentucky.

American Air Filter

BETTER AIR IS OUR BUSINESS

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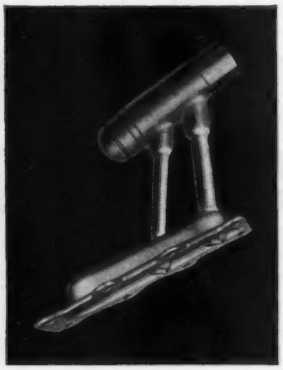
GT EDITORIALLY SPEAKING

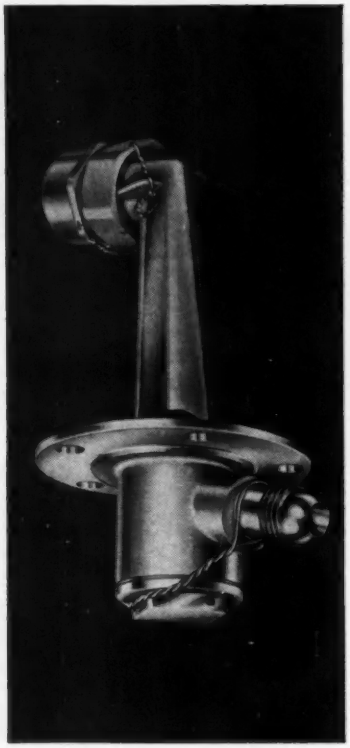
From Acorns to Great Oaks
or
State of Mind is Important

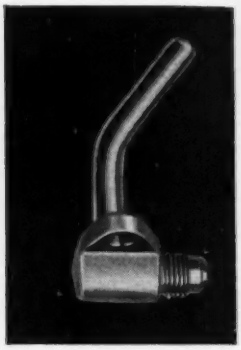
"Idea Acorns" are planted by the thousands. Some grow to great "Industry Oaks." Some don't. A lot depends on the "fertility" of the mental ground where the acorns fall. In gas turbine ground, many great oaks have grown and are growing. As witnessed at the recent Gas Turbine Conference and Products Show in Washington, gas turbines are finding uses "across the board". Pipelines, central station power plants, refineries, chemical and process plants as well as other industries are now using the big ones. This "oak" is established and is spreading. In cars, tractors off-highway equipment, amphibious vehicles, hydrofoils and other marine uses, the smaller-turbine "tree" is still a sapling but very healthy. In all these applicational fields, "idea acorns" fell on fertile ground.

It's interesting to note that within the gas turbine industry there's a wide variance in this "mental fertility". Some organizations are moving cautiously, even half-heartedly; others are moving with certainty. Some question whether they should be in the industry at all; others say that they've ridden out the worst part and are now ready to really produce! Among operators, even in industries where gas turbine acceptance is growing, there's the same broad divergence in thinking. Some say that they may switch to turbines after more study . . . others enthusiastically say that in another few years all their equipment will be gas turbine powered. So . . . the speed with which the gas turbine reaches its full potential as a prime mover depends not only on the state of the art but also on the state of mind of both the manufacturers and users. To cut this lead time we should start within the industry itself . . . develop more positive thinking, move and act with more conviction. Then we'll find users falling in line and using the gas turbine wherever its many unique characteristics provide user benefits.

R. Tom Sawyer







PROVED BENDIX EXPERIENCE CAN SOLVE YOUR FUEL NOZZLE PROBLEMS, TOO!

Bendix is exceptionally well prepared to serve as a member of your turbine design team. Our background includes 9 years of designing and producing precision fuel nozzles for jet and ramjet engines. These dependable nozzles are on engines powering jet aircraft all the way from the T-37A to the B-58.

Bendix designs solve such formidable problems as faster cold starting on the ground, and instant re-starting should flameouts occur in flight.

Bendix also works closely with major automotive manufacturers in research and experimental programs, designing fuel nozzles for gas turbines.

Our wealth of design data is available to you. Bring your fuel nozzle problems to Bendix, as many leading engine manufacturers do. Write for complete information today.

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Eclipse Machine Division
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THE Bendix CORPORATION

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GT HOT LINE

LARGEST GAS TURBINE POWERED FLEET . . .

With United and Capitol now combined they unquestionably have the world's largest fleet powered by gas turbines . . . 469 turbines are flying, of which 13 are turbofans, 164 are turboprops and 292 are jets.

BRITISH TURBINE AT REASONABLE PRICE . . .

Less than $30 per horsepower is the selling price of Austin Motor Company's 250-hp single-shaft non-regenerative gas turbine . . . Weight of complete unit is 900-lb, fuel consumption 1.06 lb/hp hr.

TURBINE-POWERED HEAVY-LIFT AIRCRAFT . . .

Design of the Sikorsky S-64 all-purpose transport helicopter, the first of a series of turbine powered heavy lift aircraft, has been completed in preparation for the manufacture of the first prototype models later this year . . . Sikorsky's S-64 is the successor to the S-60 Skycrane, a piston-driven experimental helicopter which has successfully demonstrated its unique lifting capabilities at military and shore installations throughout the East.

UNITED FUEL GAS ORDERS SOLAR TURBINE . . .

A new gas turbine-driven centrifugal gas compressor unit, designed and developed by Solar Aircraft Co. has been ordered by United Fuel Gas Co., Charleston, W. Va. Unit will be installed in a United natural gas pipeline compressor station at Spencer . . . Compressor is driven by Solar's 1100-hp Saturn T-1000. Solar's centrifugal compressors boost flow of natural gas in large pipeline systems. The T-1000 operates on fuel taken directly from the pipeline.

CHRYSLER DEVELOPMENT: VARIABLE NOZZLE TO POWER TURBINE . . .

George J. Heubner, Jr., Executive Engineer, Research, in Chrysler's Engineering Div. has produced many firsts in the gas turbine automotive field. This is an extremely important development . . . produces rapid acceleration to the car as well as engine braking characteristics . . . even improves low-speed part-load fuel consumption.

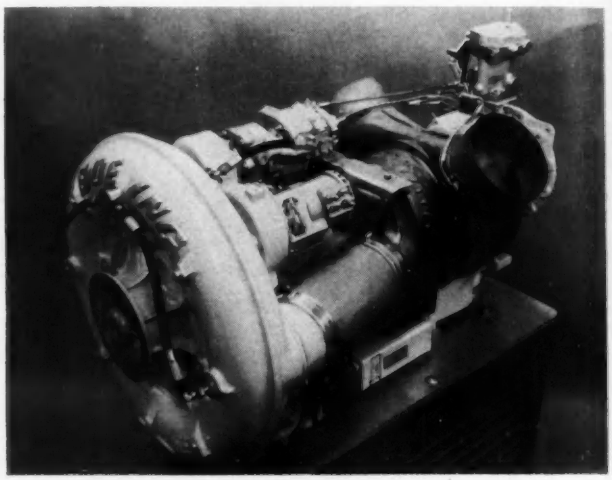
NEW GAS LINE MEANS MORE PUMPING STATIONS . . .

Humble Oil & Refining Co. announced that it is joining in the formation of a new interstate pipeline company to be known as the Monterey Gas Transmission Co., and that it will sell to the new company, by a sale of natural gas in-place in Southwest Texas, reserves of 6.2 trillion cu ft. . . . At the same time, Columbia Gas System announced that a System Company would enter into a long-term gas purchase contract under which it would purchase the gas to be produced from these reserves . . . More potential gas turbine applications.

TURBINES DO EVERYTHING . . .

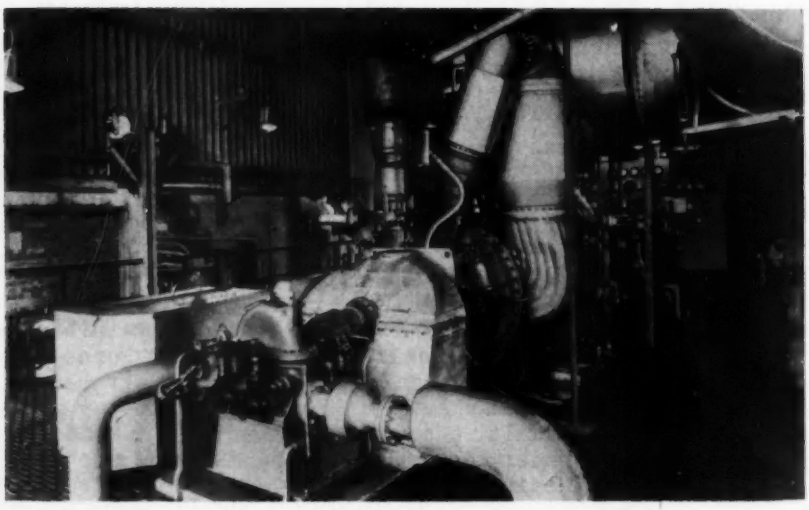
A 260,000-rpm air-bearing air-turbine dental handpiece has been built and delivered to the Air Force by Garrett's AiResearch Mfg. Div. in Phoenix. Highest-speed air-bearing handpiece yet built, the unit marks completion of the half-way point in a program to build a similar even higher rpm unit . . . Dental unit was developed and built under contract to USAF Aerospace Medical Center of Aviation Medicine.

GT INDUSTRY NEWS



Gas Turbine powers Fire Truck
This Boeing 330-hp model 502 gas turbine now powers a ladder truck for the Seattle, Wash. Fire Department and a pumper for the San Francisco Fire Department. The Seattle truck entered regular service April 14th.

30,000 Pound Thrust
Your consulting editor saw this J-58 in operation on a test stand at the Florida Research & Development Center of Pratt & Whitney Aircraft, NW of W. Palm Beach. P & WA state, "The new J-58, which is capable of powering aircraft at 3-times the speed of sound, is the first jet engine in history to be placed in the 30,000 pound thrust category.



Efficiency: 60%
Availability: 99.7%
English Electric EM27 gas turbine, in commission for 2-years at the Esso Petroleum Company's Fawley refinery in Britain, has completed 17,000 hours of plant operation without a standby. Overall efficiency with waste heat boiler 60%; availability factor 99.7%.

Self-Contained Aircraft

Five small gas turbine engines (GT-85-97) built by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona, have been sold to the Air Force Military Air Transport Service for installation aboard VC-137 aircraft to supply auxiliary power to make the aircraft self contained.

The VC-137 is the military version of the Boeing 707 jet airliner. Operated by MATS' 1254th Special Air Mission Wing from Washington National airport, the intercontinental jets provide transportation for the President, Vice President, members of the Cabinet and Congress, and other high ranking government officials and foreign dignitaries.

First Inspection at Clementsville

After approximately 1200-hours of continuous full-load operation at the Clementsville Station of Columbia Gulf Transmission Company, the Cooper-Bessemer RT-248 unit has had its first inspection. This inspection was prompted by developmental changes to the power turbine which were discussed by Cooper-Bessemer at the Gas Turbine Conference in March. These changes afforded the opportunity to thoroughly inspect all elements, including the modified J57 gas generator. (In aviation service, the J57 jet engine is inspected after 1600 hours of operation.)

Pratt & Whitney Aircraft engineers were highly pleased about the condition of all parts in the Clementsville unit. They stated that the excellent condition of "hot" parts confirmed their conviction that the industrial application with gaseous fuel and no high "take-off" temperatures and rpm's should result in vastly extended periods of operation before scheduled maintenance.

In addition to the excellent condition of the turbine hot parts, all other items including the bearings were in perfect condition and have been reinstalled in the jet engine for continuation of operation.

Bristol Siddeley Exhibits at Paris

Bristol Siddeley's exhibits at the 24th Salon International de l'Aeronautique, which opens at Le Bourget, Paris, on the 26th May will include the BS 53 lift thrust ducted fan engine, the Olympus, Orpheus and Viper turbojets, the Proteus turboprop, and the Stentor and Gamma rocket engines. A ramjet engine will also be on display in the Guided Weapons Park.

Garrett's Air Conditioning

Two contracts, one for air conditioning a hydrofoil boat, the other for an aircraft air conditioning system, have been awarded The Garrett Corporation's AiResearch Manufacturing Company of Los Angeles.

The first contract, awarded by Dynamic Developments, Inc., an affiliate of Grumman Aircraft Engineering Corporation, is an air cycle system uniquely used to cool the crew of a new hydrofoil boat.

The second contract, awarded by the Grumman Aircraft Engineering Corporation, is for an air cycle air conditioning system for the Navy's A2F-1 Intruder carrier-based attack aircraft. It is capable of receiving 860°F air and cooling it to shirtsleeve temperatures. Its flow capacity is 80 pounds per minute.

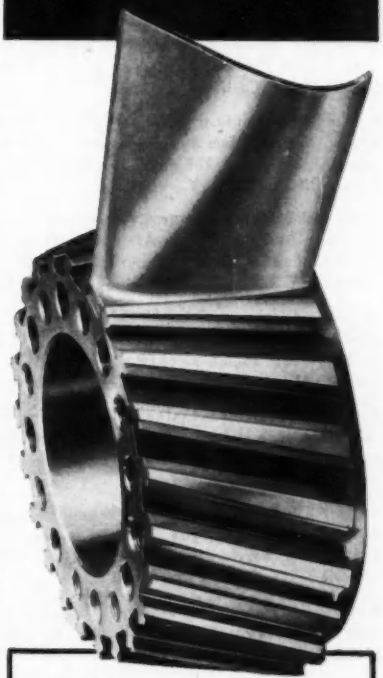
Titan Energizer Kit

A versatile energizer kit powered by Solar Aircraft Company's Titan 80-hp gas turbine engine has been ordered by the U. S. Army for testing in a YAC-1 Caribou transport aircraft, it was announced by Morris Sievert, Solar's manager of turbomachinery sales.

The kit provides 300-amps of auxiliary electrical power which can be used to start the aircraft's twin R2000 radial engines and provide power for certain ground operations when the Caribou's main engines are shut down. The energizer can also be used for cabin heating, giving the aircraft capability for extremely cold Arctic operations.

PRECISION Turbine Components

Creative engineering, experience and specialized production facilities at Poly Industries assure the highest degree of precision in manufacturing gas turbine components. Complete facilities for experimental or high production quantities of turbine blades, vanes, wheels and nozzles. Techniques for machining and forming with the toughest alloys of exotic metals are a specialty of Poly Industries.



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GT CONTRACTS PROCUREMENTS

Some major gas turbine procurements initiated and contracts awarded during recent months by various agencies of the U.S. Government are listed. This material is from the U.S. Department of Commerce publication "Synopsis of U.S. Government Proposed Procurement, Sales and Contract Awards."

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. J85 and T58 Engine Product Improvement Programs for Calendar Year 1961. Cont AF 33(600)42461—$15,307,856—General Electric Co., Small Aircraft Engine Dept., West Lynn, Mass.

• HQS San Antonio, Air Materiel Area, USAF, Kelly AFB, Texas. In-Service Engineering Services for J-65 Series Aircraft Engines, Letter Contract AF 41(608)-12968 (MIPR 19-61-7074-WEPS)—$1,250,000—Curtiss-Wright Corp., Wright Aeronautical Div., Wood-Ridge, N. J.

• Dept. of Navy Bu. of Naval Weapons, Washington 25, D. C. Conduct design and development necessary to modify two Government-owned YT62-S-2 engines to an auxiliary power plant. NOw 60-0735-d—$755,926—Solar Aircraft Co., San Diego, Calif.

• Purchasing Office, Dept. of Navy, Bu. of Naval Weapons, Washington 25, D. C. 54 Model J60-P-3 Engines in accordance with P&WA Spec. No. A-2412-C. NOas 59-8073, Amendment No. 14—$3,397,398—Pratt & Whitney Aircraft, East Hartford, Conn.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Uprating Design of T-53-L-7/L-9 Configuration, Product Improvement of T-53-L-7 Components, Reports and Data. Letter Contract AF 33(600)-42382—$750,000—AVCO Corp., Lycoming Div., Stratford, Conn.

• Purchasing Office, Dept. of Navy Bu. of Naval Weapons, Washington 25, D. C. Research and development facilities and personnel to pursue a Product Improvement Program on the YT62-S-2 gas turbine engine. NOw 61-0200-d—$150,000—Solar Aircraft Co., San Diego 12, Calif.

• AMC Aeronautical Systems Center, Wright Patterson AFB, Ohio. Facilities for the Production of Buckets and Blades and Vacuum Melting of High Temperature Alloys. Contract AF 33(600) 41739 dtd 9 Jun 1960—$160,000—Kelsey Hayes Co., Utica Drop Forge & Tool Div., Utica, N. Y.

• Purchasing Office Dept. of the Navy, Bu. of Naval Weapons, Washington 25, D. C. 46 J75-P-19W Engines less Afterburners, 34 J57-P-59W Engines, 19 TF33-P-3 Engines, 26 J57-P-55 Engines Less Afterburners and 88 J52-P-3 Engines. NOw 60-0218-i Amd No. 16—$32,562,395—Pratt & Whitney Aircraft, East Hartford, Conn.

• HQS, Oklahoma City Air Materiel Area, USAF, Tinker AFB, Oklahoma. Overhaul, Modification, Repair and Test of Turbine and Regulator Assemblies. Contract number AF 34(601)-8638, 25 Jan 61 (RFP OC-1-1660-81)—$110,267—AiResearch Manufacturing Co. Div. of Garrett Corp., Los Angeles 45, California.

• AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio. Overhaul Modification and Conversion of Government owned J33-A-33 and/or J33-A-33A Engines. Supplemental Agreement No. 12 to Contract AF 33(600)37887—3 ea—$42,000—Allison Div., GMC, Indianapolis 6, Ind.

• US Navy Dept. Bu. of Ships, Washington 25, D. C. 40 KW, 450 volt AC gas turbine driven generator set, Type II, 2 ea, Contract NObs-84258 (RFP 622C-11985)—$112,709—(Engineering Services) Spec No. MIL-G-22077 (SHIPS) as modified, Solar Aircraft Co., San Diego 12, Calif.

• HQS, San Antonio Air Materiel Area, U.S. Air Force, Kelly AFB, Texas. Spare parts and Item Identification Data applicable to T-53 Engines AF 41(608)-12995 (SA-0-0243 2840-E-13052) 1 to 50 ea—$26,029—Avco Corp., Lycoming Div., Stratford, Conn.

• Officer in Charge of Construction of Yards and Docks Contracts, Fourth Naval District, U. S. Naval Base, Philadelphia 12, Pa. Repairs to Sound Attenuation for Turbo Jet Cells, U. S. Naval Air Turbine Test Station, Trenton, N. J. (NBy-30950)—Job—$104,449—Sound Reduction Corp., East Hartford, Conn.

• Base Proc. Office, Robins AFB, Ga. Bearing, ball, annual applicable to Bank and Turn Indicator and T56 Engine Gear Assy. (RFP 61-2099)—$60,593—New Departure Div., GMC, Bristol, Conn.

• HQS, Oklahoma City Air Materiel Area, Tinker AFB, Okla. Overhaul, Modification, Repair and Test of Turbine and Compressor Assemblies. (RFP OC-1-1660-92)—Job—$258,685—AiResearch Mfg. Co., Div. of Garrett Corp., Los Angeles, Calif.

• HQS, Oklahoma City Air Materiel Area, Tinker AFB, Okla. Overhaul and/or Modification of Compressor Rotor Assembly 950 ea. (RFP OCPNA-6-61)—Job—$94,062—Southwest Airmotive Co., Love Field, Dallas, Texas.

INDUSTRY NEWS . . .

AEI Licensees

Associated Electrical Industries Ltd. now have the following licensees:

"Franco Tosi, S.p.A., Legnano, Italy, build all A.E.I. designs of gas turbines (except marine up to 6000-hp.).

Reggiane, Reggio Emilia, Italy, build marine gas turbines of A.E.I. design up to 6000-hp.

All of the following firms are licensed to build A.E.I. G.6, 7500-hp naval gas turbines. Harland & Wolff Ltd., Belfast, Northern Ireland; J. I. Thornycroft & Co. Ltd., Southampton, England; J. Samuel White & Co. Ltd., Cowes, I.O.W., England; Yarrow & Co. Ltd., Scotstoun, Glasgow, W. 4, Scotland.

Contract for CT58 Turbine

A contract in excess of $3 million for 50 helicopter gas turbine engines has been received by General Electric from Vertol Division, Boeing Airplane Company. The engine, G-E's CT58-110, 1250-hp, will be used by the Vertol Division in its twin turbine 107 turbocopter. Commercial versions of the 25-passenger 107 are scheduled to begin airline service with New York Airways later this year.

SKF's Operated at 1000°F

Experimental bearings of exotic materials and special alloys for possible use in missile, aircraft, and gas turbine engines have run at 1000°F. and above—without normal lubrication—it was disclosed by SKF Industries' Research Laboratory. It is believed this is the first time this type of bearing has run at this extreme temperature over prolonged periods and with substantial loads and speeds.

"Made of carbides, ceramics, and other specially developed heat-resisting alloys to operate at high temperatures, these rolling contact bearings operated where conventional steel bearings would fail and normal lubricants burn away," said Thomas M. Morrison, director of engineering and research.

INDUSTRY NEWS . . .

NEUC Participation Invited

The national Engine Use Council has recently been formed and is already attracting widespread interest throughout the industry, engine builders and suppliers both. Simply stated, the council's purpose is to provide an organized effort to promote the internal combustion industry and expand its potential. An 8-page booklet is offered to spell out the organization's objectives and its program to implement them. Booklet is free: use your readers' service card.

There is a vital need for an alliance of the industries interested in the sale and application of internal combustion engines. Its present concept will provide, for the first time, opportunity for the industry to act as a unit and objectively promote its best interests.

If you're interested in expanding your potential markets whether it be for engines, fuels, lubricants or accessory equipment, you need this council, and now is the time that the council can use your interest and support. Next meeting is May 1st, 9 A.M., at the Chicago Youth Club. Be there, if you can and send readers service card for the booklet.

Seminar on Industrial and Commercial GT Use

A seminar on industrial and commercial use of gas turbines will be held in Houston, June 15-16th, as announced by Southern Gas Association. The seminar—first of its kind conducted in the natural gas industry—follows closely recent publication of a research report on the application of a gas turbine to supply all energy requirements of a secondary school building, including air conditioning and high-frequency lighting (see page 32, this issue).

At the seminar, a program of interest and value to gas company engineering personnel as well as commercial and industrial sales personnel is planned. Particular attention will be given to applications, economics of operation and available equipment. Gas companies throughout U.S. and Canada are invited to send representatives.

Boeing T50 Qualification Test

The United States Navy has approved the 150-hour qualification test of the Boeing 270 shaft horsepower T50-BO-4 helicopter engine. The T50, produced by the Boeing Industrial Products Division, "is the first gas turbine in the 200 to 350 horsepower range to receive an approved 150-hour qualification rating. The rating clears the engine for installation in production Navy helicopters."

Correction

George E. Pinter, author of the article "AC Electric Drive" in the March-April issue, was omitted at time of going to press. George Pinter is Application Engineer, Jack & Heintz, Inc.

G.E. Cuts Price

The General Electric Company has announced that the price of its recently introduced gas turbine package power plant (built at Schenectady) has been reduced from $100 per kilowatt to $85 per kilowatt for the basic plant. The new price reflects a move to meet current competitive market conditions.

New Aft-fan Jet

The MF-239-C3 is being offered for the MATS SS476L cargo transport by General Electric. This engine will develop up to 23,800 lbt as compared with 16,100 lbt for the CJ-805-23. It's over a year since the CJ-805-23 aft-fan engine first flew. Neil Burgess, Manager of G.E.'s Commercial Engine Operation said, "Our first year of fan engine testing has proved beyond doubt the soundness and practicality of the aft-fan principle."

Garrett Contracts for Japanese F-104

The Garrett Corporation announced the receipt of a $3 million contract for 180 central air data systems to be installed on the Japanese version of the Lockheed F-104 Starfighter which the company is already producing.

In a previous announcement, Garrett estimated that when present negotiations are completed, the F-104 program may well be the largest production program in the history of the corporation, with a realization of total sales of about $64 million, based on approximately 1600 F-104 Starfighters on order.

The central air data system accurately senses the atmospheric environment surrounding the aircraft, computes required information and supplies it to other major systems in the airplane. These systems include autopilot fire control computer, position indicator, inertial navigator, bombing computer and landing gear warning system.

GT "COMING UP" REMINDER

MAY 7-10 American Institute of Chemical Engineers, Sheraton-Cleveland Hotel, Cleveland, Ohio.

MAY 8-10 Instrument Society of America, 4th National ISA Power Instrument Symposium, LaSalle Hotel, Chicago, Ill.

MAY 22-24 Instrument Society of America, 10th National Telemetering Conference, Sponsors: ISA, AIEE, ARS, IAS, IRE, Hotel Morrison, Chicago, Ill.

JUNE 4-8 American Nuclear Society, National Meeting, Penn Sheraton Hotel, Pittsburgh, Pa.

JUNE 4-8 Society of Automotive Engineers, Summer Meeting, Chase-Park Plaza, St. Louis, Missouri.

JUNE 6-8 Instrument Society of America, Summer Instrument-Automation Conference and Exhibit, Royal York Hotel and Queen Elizabeth Hall, Toronto, Canada.

JUNE 11-14 American Society of Mechanical Engineers, Summer Annual Meeting, Statler Hilton Hotel, Los Angeles, California.

JUNE 13-16 Institute of the Aeronautical Sciences, Summer Meeting, Los Angeles, California.

JUNE 28-30 Instrument Society of America, 2nd Joint Automatic Control Conference, Sponsors: ISA, AIChE, AIEE, IRE, University of Colorado, Boulder, Colorado.

AUGUST 14-17 Society of Automotive Engineers, National West Coast Meeting, Sheraton Hotel, Portland, Ore.

AUGUST 19-24 Institute of the Aeronautical Sciences/Naval Aviation Meeting, Classified, San Diego, California.

AUGUST 28-SEPTEMBER 1 Institute of the Aeronautical Sciences, International Heat Transfer Conference, Boulder, Col.

GT PEOPLE PLANTS PLACES

Curtiss-Wright Expands

S. Ralph Shaffer has been named General Manager and **L. B. Geithman** has been appointed General Sales Manager of the Metals Processing Division, **Curtiss-Wright Corporation,** Buffalo, New York. The appointments coincide with the Corporation's announcement of the expansion of the high-alloy steel foundry facility of the Division. The Metals Processing Division also operates a well-equipped Forging and Machine Products Plant which specialty has been jet engine blades, vanes and buckets for both aircraft and stationary engines.

Wyman-Gordon Creates New Marketing Group

Wyman-Gordon Company, Worcester, Massachusetts, engaged in heavy and light forging programs for military and commercial use, has formed a new marketing staff group, "Product and Sales Development", employing the product management concept.

The new group of Product Managers, which will work closely with the company's Research and Development, Manufacturing departments and with the field sales force scattered throughout the United States, Canada and Europe, will be directed by **Paul W. Beamer,** manager of product and sales development.

Paul W. Beamer

Richard Benson, formerly with General Electric Company in metallurgy and marketing, and a metallurgical engineer from Ohio State University, has joined Wyman-Gordon as a product manager, Gas Turbine Applications, within the department. Others in the new marketing group are **Paul J. Wisniewski,** product manager for the Nuclear and Electronics Applications; **Martin A. Komertz, Jr.,** product manager for military sales and special products; and **Thomas U. Chace,** product manager Airframe and Missile Applications.

Richard Benson

Product and Sales Development will be responsible for analyzing and developing new markets in specific industries, for providing market-oriented technical sales assistance to customers' engineering and manufacturing personnel, and for selling products directly or through the field sales staff.

Col. Rogers Back Again

Col. W. C. Rogers has returned from Korea and is now Director, Engineering, **U.S. Army,** Transportation Materiel Command at St. Louis, Mo. For many years, Col. Rogers has been a member of the General Technical Committee of the Gas Turbine Power Division of ASME.

Garrett's New Program Manager

Appointment of **James T. Shore** to the newly created post of Program Manager for Industrial Gas Turbines has been announced by J. J. O'Brien, division manager of The Garrett Corporation's **AiResearch Manufacturing Division,** Phoenix, Arizona. Shore has been serving as sales engineer in Garrett's Fort Worth office since 1959. As Program Manager he will assume management responsibility for the industrial application of AiResearch gas turbines and related products.

Neil Firestone General Manager

Neil E. Firestone has been appointed general manager of the **General Electric Company's Flight Propulsion Division** as announced by C. W. LaPierre, vice president and group executive for the Company's Electronic and Flight Systems Group.

General Electric's Flight Propulsion Division, which is headquartered in Evendale, Ohio, develops and manufactures large and small jet engines for military and commercial use, rocket and other space power and propulsion systems, aircraft nuclear propulsion systems, and aircraft accessories power equipment. It maintains overhaul, sales and service facilities throughout the free world.

Principal components of the division are the Large Jet Engine Department, Flight Propulsion Laboratory Department, Aircraft Nuclear Propulsion Department, Commercial Engine Operation and Field Sales Operation (all located at Evendale), and the Small Aircraft Engine Department and Aircraft Accessory Turbine Department (both located at West Lynn, Mass.)

Harold W. Austrow

H. W. Austrow at "Condec"

Harold W. Austrow has joined the aircraft equipment division of **Consolidated Diesel Electric Corporation** as chief engineer. He succeeds Albert A. Sackler, who has been named special assistant to Jerome I. Davis, vice president and general manager of the division. Mr. Austrow will be in charge of all engineering activity on Condec's line of aircraft and missile ground support equipment and special-purpose vehicles.

Williams Research Names Engineering V-P

John F. Jones, chief engineer of Williams Research Corporation, Walled Lake, Michigan, has been named engineering vice president by Sam Williams, the company president.

In announcing the promotion, Williams said Jones has been associated with the company for the past six and a half years and "has been a principal factor in the company's successful development of gas turbine engines." These developments include the world's smallest aircraft turbojet engine, a 75-hp turbine, currently being installed in an Army Jeep, a 400-hp truck and industrial turbine to be manufactured by the Waukesha Motor Company, and the world's first gas turbine outboard motor which is being manufactured by the Outboard Marine Corporation for use in small craft by the U.S. Navy.

Jones received his bachelor of science degree in mechanical engineering from Case Institute of Technology in 1941 and masters degree in automotive engineering from Chrysler Institute of Technology in 1943. He then spent 13½ years with the Chrysler engineering division where he was associated with various research projects including gas turbines.

Garrett Enlarges Phoenix Plant

To facilitate increasing expansion of its activities in aircraft, missile and space programs, The Garrett Corporation has announced the acquisition of 24 acres of land and a 60,000-sq ft. office-factory building adjacent to its AiResearch Manufacturing Division of Arizona at Phoenix.

This is the second sizeable land and building addition at the Phoenix location since 19 months ago when Garrett acquired another adjacent 135,000-sq ft plant and office building on 33 acres adjoining the Phoenix airport. The newest property brings the size of the entire Arizona plant to a total of approximately 100 acres and 675,000-sq ft of manufacturing, laboratory, warehouse and office space under roof, according to J. J. O'Brien Manager.

IF NOISE

IS A PROBLEM . . . CONSULT

GENERAL ACOUSTICS

SPECIALISTS IN GAS TURBINE NOISE SUPPRESSION EQUIPMENT

INTAKE EXHAUST ENCLOSURES

Aircraft *Marine*
Helicopter *Missiles*
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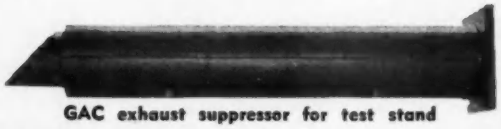
General Acoustics is the foremost engineering firm working exclusively in the field of noise suppression—eliminating high noise levels caused by gas turbine engines. Write for full information



GAC exhaust suppressor for test stand

GENERAL ACOUSTICS CORPORATION
12248 Santa Monica Blvd.
Los Angeles 25, California

For more information write in No. 70

SPEED SENSITIVE SWITCHES

With 1, 2, 3, 4, 5 or 6 adjustable switches in the same size container illustrated.

Any drive mountings listed which would best fit the installation can be used with any of our speed switches. The GS model will accommodate a coupling, gear or a pulley for other means of driving.

Normal speed can be as high as 7000 RPM. Low speed setting can be as low as 200 RPM if the top speed is below 2500 RPM. A governor that will make contact at 20 RPM is available.

A variety of caps and terminals are available. Request Bulletin 604.

SYNCHRO-START PRODUCTS, INC.
8151 N. RIDGEWAY AVE.
SKOKIE, ILLINOIS

For more information write in No. 71

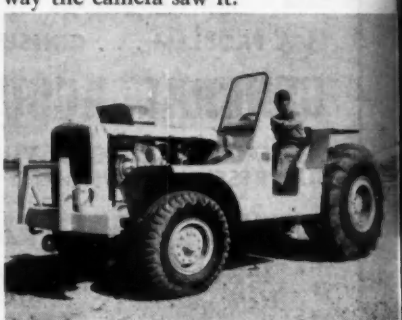
Chrysler display showed their variable-nozzle turbine.

View under hood of Chrysler's outstanding gas turbine car, with body by the Italian coachbuilder Ghia. Another car, Plymouth's X-7, was in operation at the Pentagon. Also, a Chrysler truck equipped with a gas turbine was in operation.

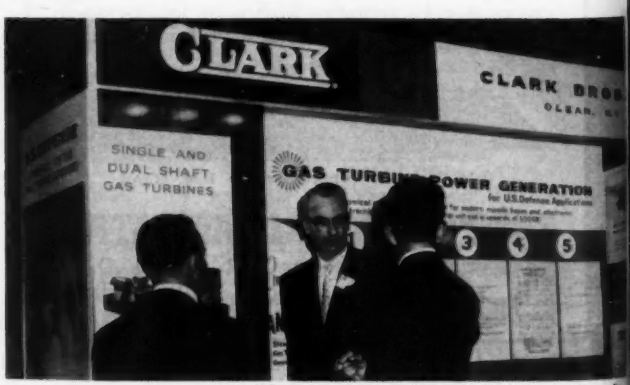
SIXTH ANNUAL

GAS TURBINE CONFERENCE and PRODUCTS SHOW

Attendance included 912 persons representing 279 companies. These represented government and industrial users, gas turbine and accessory manufacturers. They saw products of 36 exhibitors occupying 60 booths. Here's the way the camera saw it.

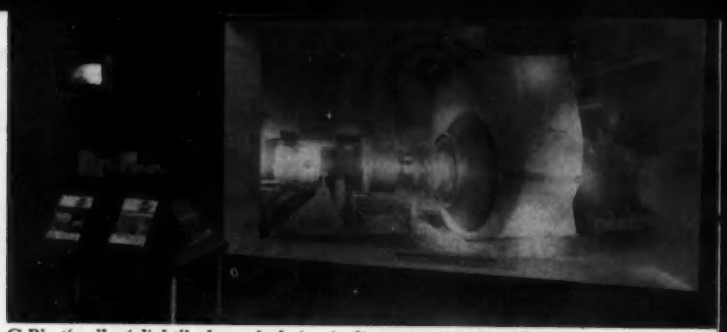


Allison's GMT-305 powered tractor displayed at Pentagon.

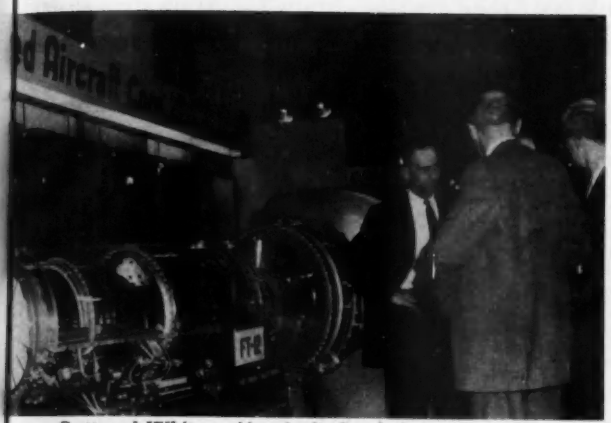


Clark concentrated on H-D industrial units.

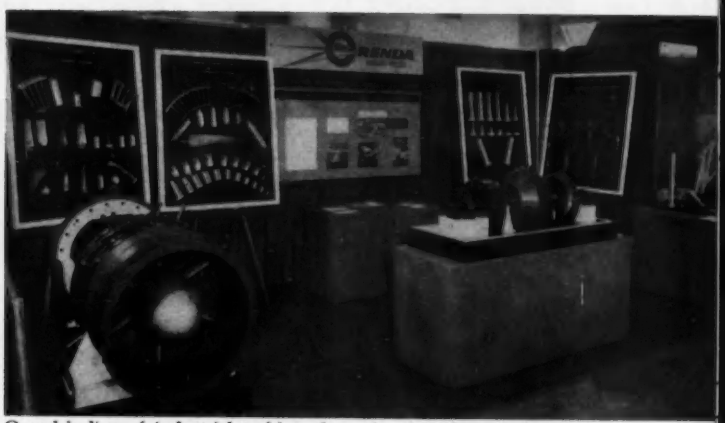
Sulzer showed model of gas turbine powered plant



C-B's "wall of light" showed their pipeline pumping installation.



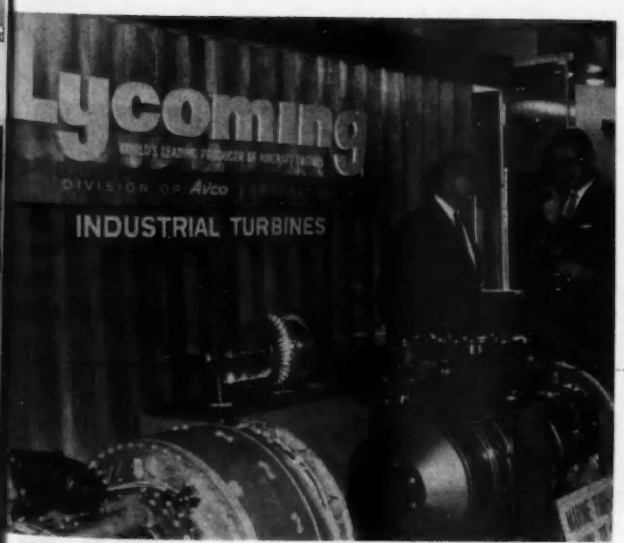
Pratt and Whitney Aircraft displayed their industrial jet unit.



Orenda's line of industrial turbines from 600-6000-hp was featured.

GE showed shaftpower hydrofoil gas turbine unit.

Waukesha showed their turbine developed with Williams Research Corp. Williams showed a line of their products.



Lycoming demonstrated their line of industrial turbines.

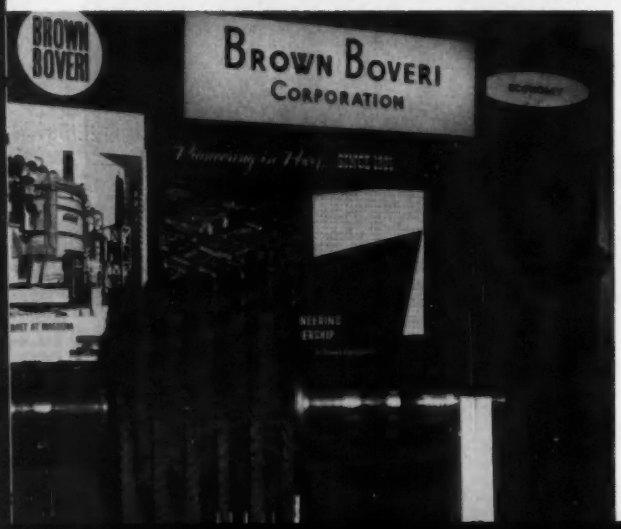
AiResearch showed complete line of turbo machinery.

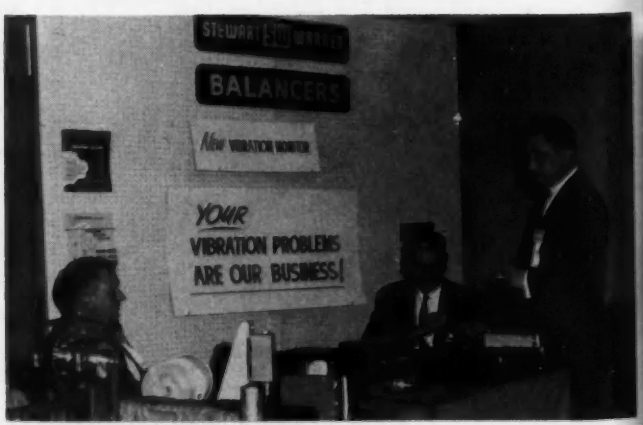
6TH ANNUAL GAS TURBINE CONFERENCE AND PRODUCTS SHOW

Displays of the accessory manufacturers demonstrat

Three Bendix divisions showed product line for the turbine industry.

Inco demonstrated typical uses of nickel bearing alloys.





Stewart Warner featured balancing equipment.

...mponents.

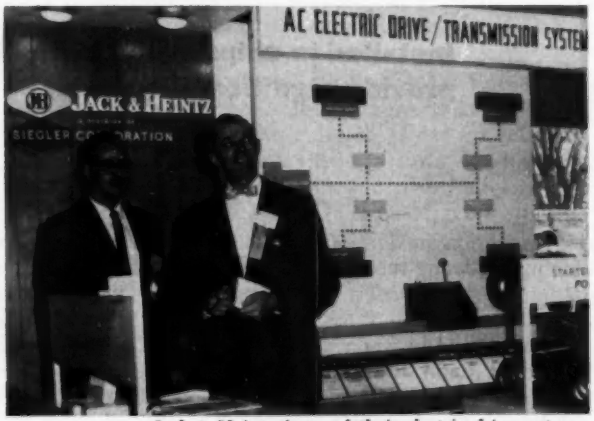
Utica Drop Forge showed blading and other products.

Delavan showed nozzles, injectors and igniters for turbine use.

Aerotest showed extensive test facilities available to the industry.

AC Sparkplug Electronic Div. showed fuel controls, ignition systems; Universal Cyclops, better steels for turbine use.

Harrison's heat exchanger capability ran from miniature to mammoth.



Jack & Heintz featured their electric drive system.

Koppers divisions stressed couplings, seals and silencing equipment.

Woodward—governors and fuel controls.

Gas Turbines Add Fighting Punch

Abstracted from the paper "Seapower: Gas Turbines Add Fighting Punch", by Ralph K. James, Chief, Bureau of Ships, Navy Department, Washington, D. C., March 1961, American Society of Mechanical Engineers.

Installed in ships, amphibs and support equipment, gas turbines provide significant advantages in many applications.

Rapid expansion in development and use of the gas turbine in increasing the fighting effectiveness of Naval ships, amphibious vehicles, and supporting equipment is taking place. Growth of gas turbine usage in the U.S. Navy is illustrated in Fig 1.

Dependent upon the application, the gas turbine may have any of the following military advantages:

(a) More power per unit weight.
(b) More power in a given volume.
(c) Lower acoustic signature.
(d) Lower installed cost.
(e) Easier maintenance.

Considering the first of these, the gas turbine's high power/weight ratio gives it a tremendous advantage in many applications. Every increased ton of machinery weight in a ship means an increase in size of hull required to float it. Increase in hull size means need for more horsepower to drive it at its specified speed, increased ship construction costs, and an increase in maintenance and operating costs during the lifetime of the ship.

The increased cost per additional ton of machinery weight varies widely with ship type, and in some cases with the location aboard ship. In a slow auxiliary-type ship which is volume-limited, weight saving is of very little importance. But in very high-speed craft such as hydrofoils, for flight-deck equipment in aircraft carriers, or for machinery located above the main deck in destroyers, an increase in weight becomes very costly.

Hydrofoil Craft

Among current programs which capitalize on the high power/weight ratio of gas turbines is our 108-ton hydrofoil patrol craft, the PC(H), now under construction by the Boeing Airplane Company. This anti-submarine craft is intended to stay at sea on station for extended periods, traveling at relatively low speeds while floating in the displacement condition, utilizing its sonar gear to detect submarines.

To give the PC(H) a high-speed attack capability this craft is fitted with hydrofoils and two 3800-hp Bristol Proteus marine gas turbines. By lifting the hull clear of the water, the enormous frictional drag of the large hull at high speeds is eliminated, allowing much

higher boat speeds. More important, in high waves the fully submerged foils are so controlled that the boat is at minimum height above the water at the crest of a wave, and at maximum height above the water at the wave trough. This greatly smooths the ride path in comparison with more conventional hulls, giving the PC(H) the all-important high attack speed in rough water.

Many other designs on the drawing boards capitalize on the new dimension that the hydrofoil brings to sea warfare. To insure realization of full potential of this unique craft, a 280-ton research hydrofoil is being planned to help solve problems that abound in application of this new development to larger ships. This craft, known as the AGE(H), will require up to 60,000-hp for main propulsion, and considerable additional power for auxiliary uses. Only gas turbines provide a practical plant within the weight and size limits faced.

Ship Conversion

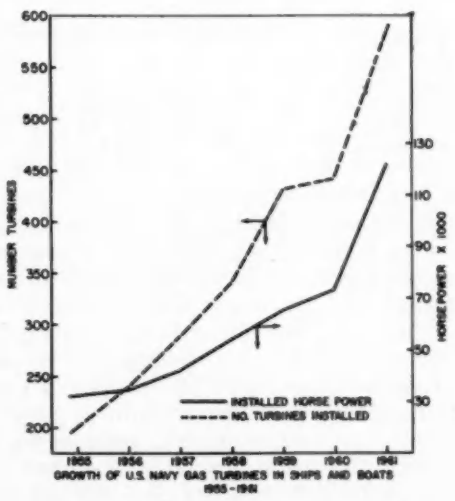
When craming maximum possible power into a fixed volume, a frequent problem in backfitting and ship conversion programs, the gas turbine's small size is of tremendous value. A recent example was the requirement late in the conversion period to increase substantially the electrical generating capacity of the guided missile cruiser USS Oklahoma City (CLG5). A 750-kw generator powered by a gas turbine was fitted into a space formerly used as a passageway. The extensive rearrangements required to install this additional power by any other means would have been extremely costly in both time and money.

Supercharged Boilers

Great savings in volume of boilers for steam turbine power plants can be made by putting the fire-box under high pressure through use of a gas turbine supercharger. Firebox volume is reduced, heat-transfer rates are greatly increased, and much of the high-level temperature drop of the combustion gases takes place in the gas turbine instead of in the bulky tube nests of conventional boilers.

Following extensive simulated service testing at the U.S. Naval Boiler and Turbine Laboratory at the Philadelphia Naval Shipyard, newly developed Foster-Wheeler "pressure-fired steam generators," equipped with gas turbine-superchargers, are being used in two destroyer-escorts of the current shipbuilding program (DE 1040-1041). Use of these compact steam generators, made practical by use of gas turbines, will enable a 75% increase in propulsion shaft horsepower of our destroyer escorts with no increase in size of machinery spaces, and very slight increase in overall machinery weight.

This additional power gives these ships greatly increased fighting effectiveness when pitted against modern high-speed submarines. When proven at sea, it is expected that pressure-fired steam generators will allow reductions in ship size and construction costs through similar reductions in machinery size and weight in other type ships.



In the past five years, installed horsepower has increased 91%; number installed, 104%

Amphibious Tank

Another application in which minimum volume is of extreme importance is the amphibious tank. Overall size of these vehicles is limited by requirements of transportability aboard attack ships of the amphibious forces. With size (and hence displacement) limited, any extra weight requirements for machinery or armor must be compensated by reduction of payload or armament. Also, armor protection must extend around the main propulsion engines, further emphasizing the importance of engine size.

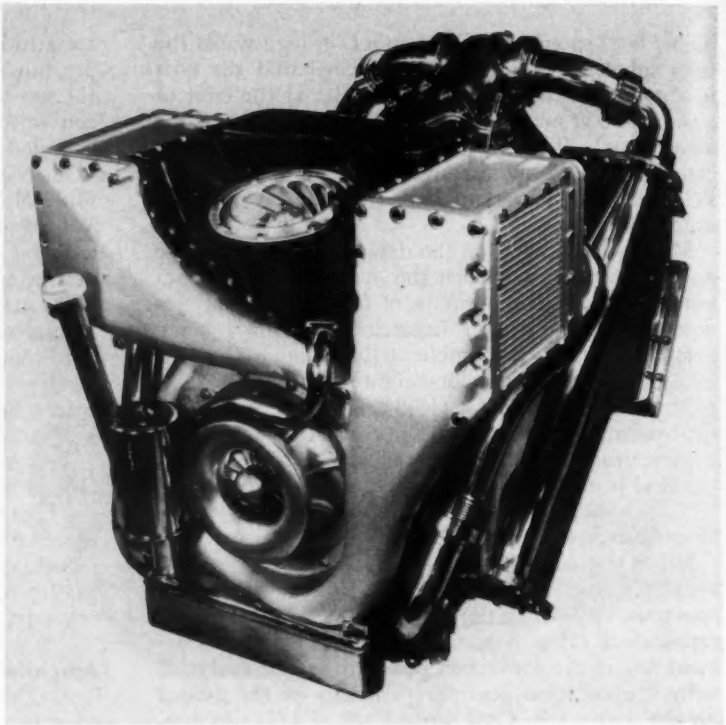
An extremely compact 800-hp gas turbine, another Navy-sponsored development, is being evaluated in a prototype LVTP, an armored 42-ton amphibious tracked vehicle. Use of this gas turbine allows a 66% increase in payload over the identically-sized vehicle currently in use. The LCA, a larger 60-ton tracked amphibious assault craft, uses two 1100-hp gas turbines. Gas-turbine power is also projected for the high-speed wheeled amphibian, the LVW, and for the very high-speed hydrofoil Amphibious Support Vehicle, the LVH.

Minesweepers and ASW Craft

As electronics and sonar become more sophisticated the limiting factor in submarine-detection capability is the self-noise of ASW ships. This problem of acoustic signature is also of primary importance to minecraft, whose effectiveness and safety depend upon their relative immunity to acoustic (as well as other) mines.

Gas turbines have particularly favorable characteristics from an acoustic signature viewpoint. Their noise is largely in the high-frequency spectrum, which tends to attenuate rapidly and which can be easily treated without bulky insulating means. More important, the gas turbine is a self-contained unit inherently small and light in weight. This makes it simple to sound-mount and hood to attain any required reduction in trans-

(Continued on page 29)



Ford Motor Co.'s 300-hp turbine for truck use.

STATUS REPORT:

Gas Turbines in the Automotive Field

The necessary development work has been or is being done.

When are we going to have gas turbines in cars? Nobody knows the exact answer for sure, but the trend of development indicates that the answer is within the next five years. The sequence of the progression has already shaped up.

First, as gas turbines developed, the orientation was toward stationary application. This phase is now completed. Second, the proven stationary units are modified for marine use. This phase, also, is now completed. Third, lessons learned developing stationary and marine gas turbines are applied to developing vehicular turbines.

In the beginning, vehicular applications are directed toward the heavy-duty, or truck field. Later, refinements in weight and bulk, as well as simplification of operation, evolve the gas turbine into ordinary everyday automotive application. We are now experiencing this phase of development. Let's take a look at what the principle manufacturers are doing.

Allison Division of General Motors have over a dozen of their GMT-305's in service in many types of heavy-duty vehicles ranging from ore trucks to tractors and amphibious vehicles. This unit is now being redesigned for production purposes and may be available in its new version for much broader use in 1962. Its fuel consumption is better than that of a gasoline engine due to its regenerator.

Boeing was the first to have a turbine in a truck. This was, say, 10 years ago. Today, Boeing has powered two fire trucks. They are pushing their 270-hp turbine for automotive and marine use. At the New York Motor Boat Show they quoted $15,000 per unit, without heat exchanger, which is the lowest price quoted yet for a gas turbine of this rating. It is an ideal marine turbine but needs refinements for automotive use.

Chrysler stole the recent Gas Turbine Products Show with an operating Plymouth, an operating Dodge truck and a beautiful show car, body built by Ghia of Italy. Chrysler announced variable stator blading in the gas turbine giving complete control of power flow, a must for a gas turbine auto and preferred for other vehicle uses. Chrysler is now ready to do business in a very limited way in selling their highly-efficient gas turbine. Their gas turbine car, reporterly, will not be ready until about 1965.

Continential Aviation and Engineering Corporation's new model 217 has a separate power turbine and is therefore suitable for operating vehicles. Its rating is 400 to 500 horsepower, which limits its possible applications to heavy-duty vehicles.

Ford Motor Company has tried various gas turbine designs through the years and is now completing the development of the "704," a normally designed unit plus turbocharger. This 3-shaft arrangement produces a very low fuel consumption which approaches the diesel even at part load. The "704" is rated 300-hp, and is specifically designed for truck operation.

Garrett Corporation's AiResearch Division has designed a 350-hp unit with heat exchanger, weighing 450-lbs and having a fuel consumption of 0.45 lb/hp hr. (See page 26 March-April issue.) This article also says, "This new prime mover should not be considered just as a replacement for a reciprocating engine. It has its own characteristics and can do more."

General Electric has its 700-hp model 720 in an 80-ton amphibious vehicle, installed by Jered Industries. It will be interesting to see the operation of this unit as it features variable stator blades in the compressor. They state that only 3 seconds is required for acceleration from no load to full load.

Lycoming Division of AVCO has turbines that are normally used in aircraft but certain units have been specifically redesigned for both marine and automotive use. As the lowest rating is 700 horsepower, their turbines would have to be used in heavy-duty vehicles.

Orenda Engines Ltd. is developing a 600-hp unit suitable for heavy-duty vehicle application. This is their smallest unit in a line of industrial turbines.

Pratt & Whitney Aircraft has a unit of 400-500 horsepower which they have considered modifying for vehicular use. Again, this would be for large trucks and heavy-duty equipment.

Solar Aircraft Co., now owned by International Harvester, is building a heavy-duty turbine for truck application. As Solar is building several sizes of turbines, it is in a good position to meet any competition when the time comes.

Waukesha Motor Company has a 400-600-hp turbine being developed by Williams Research Corp. This will fit into the heavy-duty engine field that Waukesha is now in.

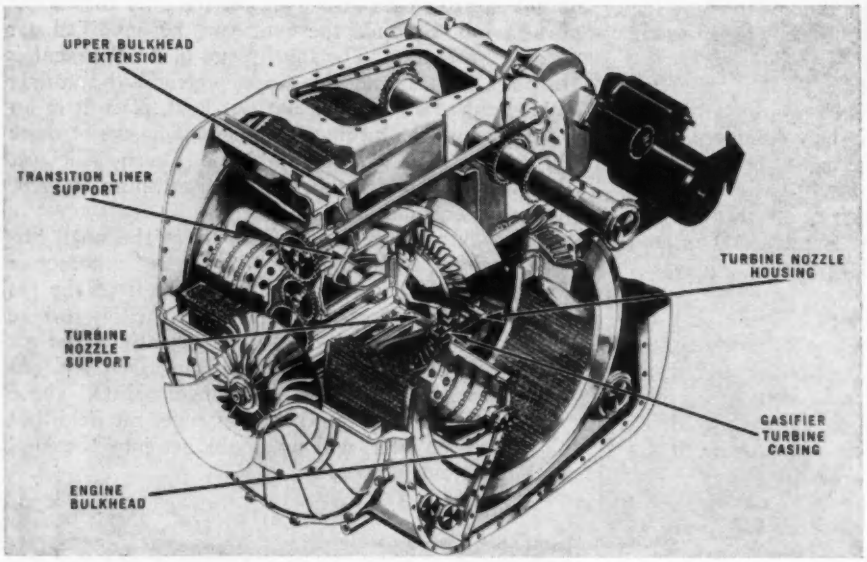
Williams Research Corp., is developing other turbines in addition to the Waukesha unit. There is a 125-hp unit being developed for Outboard Motor. By this summer a jeep should be operating with a Williams 75-hp turbine, the contract for this being with Ordnance Tank Automotive Command at Detroit. This company is in a position to move fast in developing practically any size of automotive turbine.

SUMMARY

It appears that the normal progression is to first build a turbine for stationary service . . . this is the easiest job. Second, the unit can be modified for marine propulsion. The third phase of development is to place it in automotive work, preferably heavy-duty truck work and then last, but not least, place it in an auto. Placing the turbine in an auto is no doubt more difficult than any other application, even if it just drives the car, not to mention the furnishing of light, heat and air-conditioning.

With over a dozen manufacturers in the small turbine business, including the "Big Three" automotive firms, the trend is definitely towards use of the gas turbine in the automotive field—and the gas turbine car is a certainty by 1965. In the meantime, the gas turbine should move into the trucking field and off-highway equipment. All the companies listed above will certainly not get into the passenger car field, but all, sooner or later, will no doubt get into the land transportation business.

Williams Research Corp.'s 75-hp gas turbine in Jeep. Installation in process for Ordinance Tank Automotive Command, Detroit. Left to right: Sam Williams, Pres.; Jack Benson, Eng.



Cutaway of the Allison GMT-305 Whirlfire shows the vital components that are cast in CF-8C columbium-containing stainless alloy.

GM Uses Castings Effectively

High-alloy castings in the hottest sections of "whirlfire" confine and utilize hot gases in vehicular gas turbines.

Problems of high temperature, corrosive combustion products and high stress are inherent in vehicular gas turbine engines. Engineers of the Allison Division of General Motors Corporation have approached solution through liberal use of high-alloy castings in design of the GMT-305 "Whirlfire" regenerative gas turbine engine.

To handle the combination of extreme operating requirements in such a highly concentrated weight-size "package," castings made of SAE 60347 alloy (Alloy Casting Institute designation CF-8C) are used for six important components in the "hot area" of the Allison engine (illustrated).

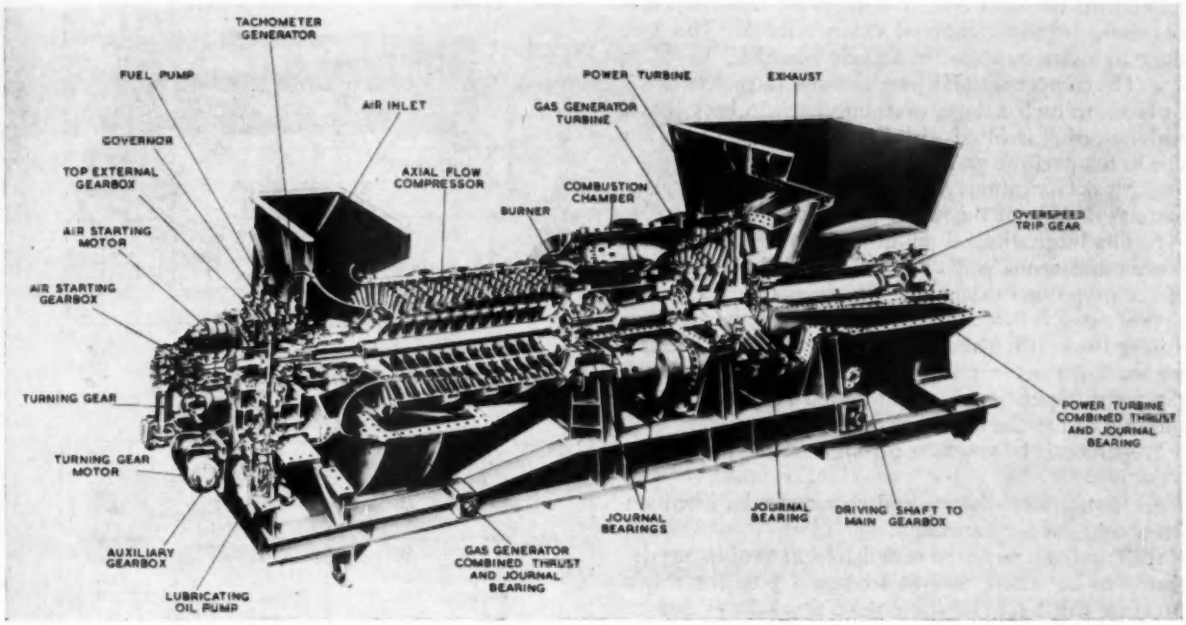
Location of these castings is in the hottest sections of the engine and their function is to confine and utilize extremely hot combustion gases. This points up the necessity of using a metal having good temperature and corrosion-resistance characteristics while, at the same time, having sufficient strength and other physical properties to withstand the high thermal and mechanical stresses encountered.

Type CF-8C is an iron-base, columbium-stabilized, chromium-nickel alloy especially formulated to resist corrosion in services involving long exposure to elevated temperatures. Castings of this alloy have good machinability and weldability, high hot strength and a limiting creep stress well above working requirements. Chemical composition of the alloy is as follows: C-0.08 max; Mn-1.50 max; Si-2.00 max; Cr-18-21; Ni-9-12; Cb- (8 x C min—1.0 max).

In the solution heat-treated condition, CF-8C has an essentially austenitic structure. When exposed to temperatures in the 800-1600°F range for long periods, columbium carbides are precipitated instead of chromium carbides; this circumstance prevents depletion of chromium along the grain boundary network and the alloy, therefore, there is protection against intergranular corrosion attack.

According to Allison engineers and metallurgists, the most important properties from the manufacturing standpoint were good castability, machinability and weldability. From the functional viewpoint they were faced with considerations of: (a) warpage due to heat and pressure differentials, (b) creep stress limit because of the high temperatures under which the metal operates, and (c) corrosion resistance. Combining all these requirements with the economics of production costs tipped the decision away from wrought construction and in favor of CF-8C castings.

That the CF-8C castings have met the challenge of extreme chemical and physical environmental conditions is now a matter of record. Many of these GMT-305 prototype units are now in service giving a good account of themselves.



Power for naval boost propulsion

Details of a 7500-shp gas turbine designed for application by the British Navy in two classes of ships.*

Associated Electrical Industries' G.6 gas turbine, 7500-shp output, forms part of the combined steam-turbine/gas-turbine propulsion machinery currently being installed in two classes of British naval ships. Design specifications included some requirements of a novel nature.

Design studies were carried out by Yarrow-Admiralty Research Department, in close collaboration with the Admiralty and Associated Electrical Industries, into the best arrangement of propulsion machinery for two projected classes of ship, General Purpose Frigates and Guided Weapon Destroyers.

This led to the conclusion that steam turbines, of reasonably advanced steam conditions, should be used for normal propulsion and maneuvering, and that the upper portion of the power range, only rarely used in these classes of ship, should be provided by gas turbines. Various ratings were considered for the gas turbine plant, and 7500-hp, measured at the propeller shaft, was selected.

Frigate and destroyer installations each used the same gas turbine, the G.6, with only minor installation differences. Frigate machinery included one gas turbine and one steam turbine, driving into a common reduction gear on one propeller shaft. Destroyer machinery consisted of two propeller shafts, each powered by one steam turbine and two gas turbines, all three driving into a common reduction gear.

Design Requirements

The G.6 gas turbine, rated 7500-shp at 59°F ambient air temperature, had a specified life of blading at full load of 1000 hours. This output had to be developed under conditions of duct pressure losses of 0.65 psi and with an inlet silencer.

Severe shock acceleration had to be withstood. An additional requirement was that the gas turbine had to be airtight, so that air passing through the machine did not leak into the engine room. Also the machine had to be capable of operation partially submerged in water.

The cycle chosen required a compressor pressure ratio of 6.3 and a turbine inlet temperature of 1460°F. The predicted specific fuel consumption at full load was just over 0.72 lb/shp-hr.

Details of Construction

Some principal features of the G.6 gas turbine are listed:

1. The combustion chamber consists of six flame tubes. This permitted the complete machine to be split horizontally to provide ready access for maintenance and inspection.

2. Compressor blading is aluminum bronze which had the highest fatigue strength, in a marine atmosphere, of any alloy available at the time materials were being selected.

**Abstract from the paper "A 7500-shp Gas Turbine for Naval Boost Propulsion" by F. R. Harris, Chief Engineer, Gas Turbine Department, Associated Electrical Industries, Ltd., Manchester, England, presented at ASME Gas Turbine Power Division Conference, Washington, D. C., March '61.*

3. Compressor fixed blading is unshrouded at the outlet end. At the inlet end, five stages are built into diaphragms, as in conventional steam turbines. This was done to insure freedom from blade vibration.

4. The compressor (HP) turbine and the power (LP) turbine are each 2-stage, overhung back to back. Each turbine casing is fitted with liners to reduce distortion due to temperature gradients.

5. Steel fabrications are used in place of light alloy castings because of the severe shock requirements.

6. The lubricating oil pump is driven from the compressor and forms part of the main lubricating system of the propulsion machinery.

7. Starting is by compressed air. Six motors are used, driving through sun-and-planet gears on to the compressor shaft. An over-running clutch is provided for disengagement. Operation is on air stored at 3000-4000 psi and supplied to the motors at 600 psi.

8. Ignition is by magneto, driven from the starter gear train.

9. All top half castings and rotors can be lifted on screw columns for inspection.

10. Turbine is mounted completely on a subframe, designed to be strong enough to transmit to the ship's structure the forces arising out of shock loads due to underwater explosions.

11. The fuel control system is provided with interlocks to ensure safety of the gas turbine and its maneuvering gear under all conditions of operation.

Testing

The first gas turbine was programmed for completion some time ahead of its reduction gear so testing with power absorption by the conventional method was not immediately possible. By running with a variable-area nozzle in place of the LP power turbine, it was not difficult to run the compressor and its HP turbine over a wide range of operating conditions, including full load, without use of reduction gear or dynamometer.

This facility has been of great value. The G.6 turbine is being manufactured in Britain by several shipbuilders as well as by Associated Electrical Industries. Therefore, the expense of several sets of power-measuring equipment could not be considered. By running with a nozzle in place of the LP turbine, the gas generator portion of each machine was given a mechanical run to full load. Sufficient test readings were obtained to enable reasonable predictions of performance by direct comparison with the prototype machine tested both with a nozzle and with a dynamometer. No major design modifications were found necessary as the result of the experimental testing but a great many minor improvements resulted.

The compressor was rig-tested in three slightly different configurations before running the gas turbine. Characteristics of the three types were closely similar and those of the type actually used are shown in Fig. 1. Surge pressure ratio of this compressor at medium and upper speeds was surprisingly high.

Possibility of removing stages from the compressor output end without sacrifice in performance was considered and one machine was built with an 11-stage com-

(Continued on page 30)

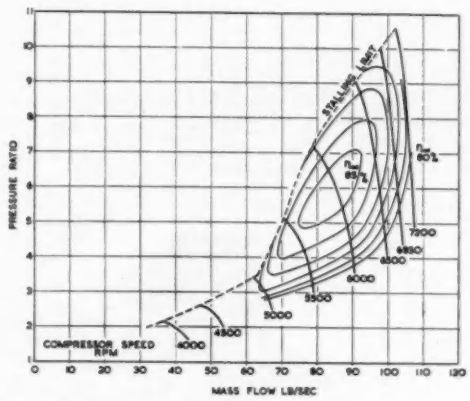


Figure 1—Compressor performance.

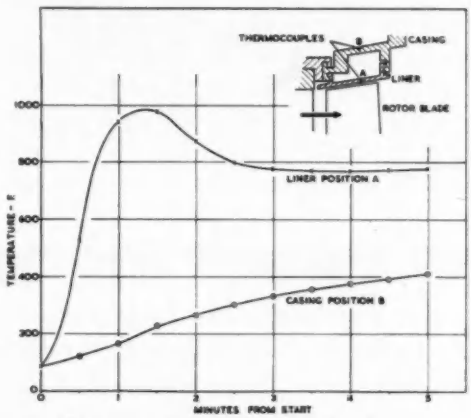


Figure 2—Relative heating rates of turbine casing and liner during a normal start.

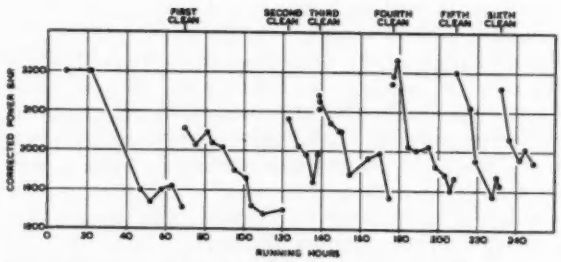


Figure 3—Power output checks on a G.1 gas turbine at the same compressor speed (7400-rpm) over a long period of seat trials, showing the effect of water spray cleaning.

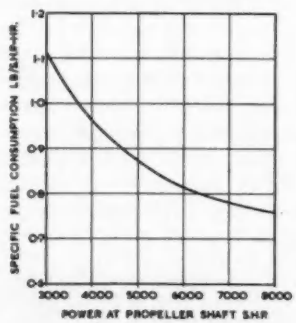


Figure 4—Specific fuel consumption.

TARGET: BSFC of 0.4

Joint Army-Navy program awards development contracts to Ford and Solar.

A joint development program has been launched by the Army and Navy to produce a 600-hp gas turbine that will meet the needs of the two services. This new prime mover is required to fill specific demands that cannot be met with either diesel or gasoline engines.

Development specifications call for:

Output: 600-hp maximum at 80°F.
Specific fuel consumption: 0.4-lb/hp hr from 40 to 100% power
Weight: less than 2.5-lb/hp
Volume: less than 50-cu ft
Overhaul interval: 1000-hours at 600-hp.; 5000-hours at 500-hp.
Purchase cost of production units: $20/hp

Proposed application for this new turbine, in both branches of the Defense Department include: truck, tank, boat propulsion, pump compressor and generator drives. It is expected that this turbine will also find wide use in the industrial field. This is a most important factor in ultimately approaching the goal of $20/hp.

Rear Admiral R. K. James, Chief of the Navy's Bureau of Ships recently announced that Ford Motor Company, Detroit, Michigan and Solar Aircraft Company, San Diego, California had been awarded contracts for the joint Army-Navy development of this turbine.

Estimated cost of the program with the two firms is approximately $9.5-million. Each of the two companies will bear a portion of the estimated development costs.

Objective of the program is to develop a gas turbine having a specific fuel consumption as good as that of the diesel engine and better than that of the gasoline engine. This, combined with light-weight, small volume, low maintenance, good reliability and ease-of-starting characteristics of the gas turbine, all specified in the development program, should find it a wide range of applications in military fields.

VEHICLE PROPULSION
MARINE PROPULSION
A SOLAR-DESIGNED CENTRIFUGAL COMPRESSOR!
NEW 600 HP. GAS TURBINE
BEING DEVELOPED BY SOLAR WITH JOINT ARMY-NAVY SPONSORSHIP FOR WIDESPREAD MILITARY AND INDUSTRIAL APPLICATIONS.
Target Characteristics are:
1. Specific fuel consumption, 0.40 lbs./hp-hr.
2. Cost and life competitive with production reciprocating engines.
3. Simple cycle regenerative design to maintain inherent turbine advantages of compactness, light weight and high reliability.
4. Fuel versatility: Diesel, gasoline, natural gas etc.

Cut-away of the Solar gas turbine.

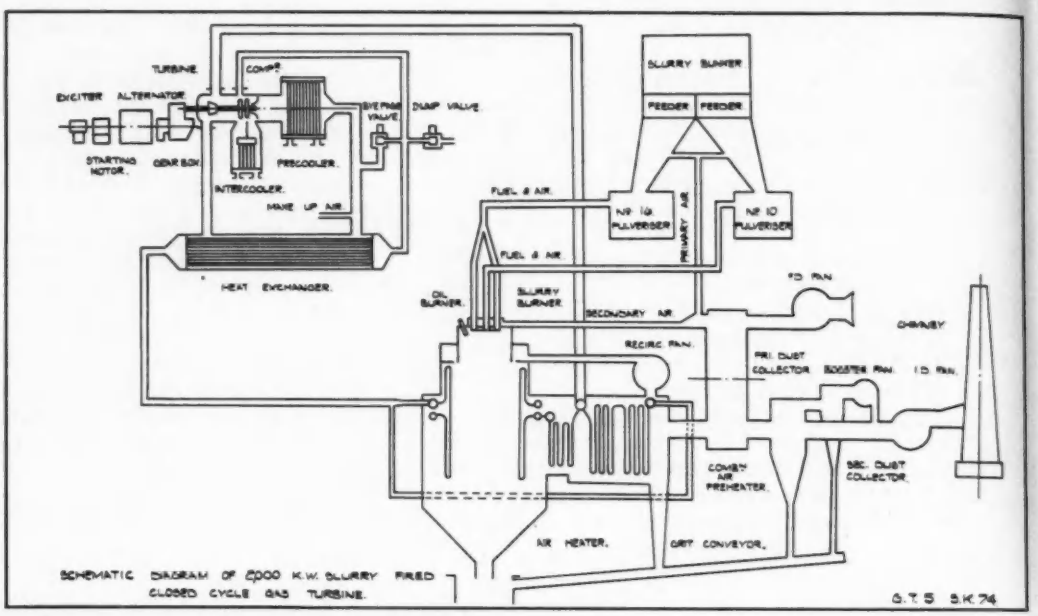
Ford Motor Company Development

The 3-year research and development contract was awarded to Ford following a design competition among a number of the major companies active in the gas turbine and aircraft engine field. The contract, negotiated by Ford's Special Military Vehicle Operation, calls for a compact, light-weight turbine with fuel economy equivalent to that of a diesel engine. Design, fabrication and testing will be done by the Turbo-Machines Department, Engineering and Research Staff of Ford.

Power requirement is exactly double that of Ford's recently announced "704" gas turbine, which delivers 300-hp. The cycle for the "704" turbocharged turbine is shown. The "704", a major break-through in gas turbine design, is the first small engine of its kind capable of delivering both full and part-load fuel economy equivalent to that of a diesel.

(Continued on page 30)

Gas turbine—alternator package is at upper left. Remainder is coal slurry burner that supplies heat energy to the closed gas loop.



Gas Turbine Burns Coal Slurry

Performance is satisfactory from 2-MW coal slurry-burning closed-cycle gas turbine.

by William Connell, Manager
Gas Turbine Department
Messrs. John Brown & Co., (Clydebank) Ltd.
Clydebank, Scotland

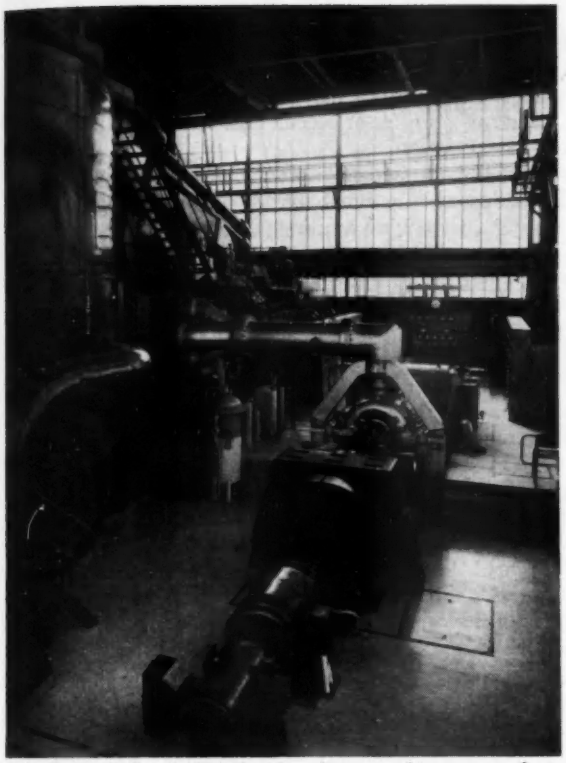
Early last year, construction of a 2-MW coal slurry-burning closed-cycle gas turbine was completed by Messrs. John Brown & Co. (Clydebank) Ltd., for the National Coal Board at Rothes Colliery, Fife, Scotland.

After some preliminary running on oil fuel, coal slurries containing 50% inerts and with a high heat value of 6500 Btu's per lb were used and, to date, some 2000 hours running on load have been achieved. Performance of the gas turbine has been satisfactory throughout and considerable progress has been made in handling, pulverizing and burning coal slurries. The ultimate aim is to accept all qualities of slurries, thus avoiding need for selection.

In Fig. 1 the closed power circuit is easily distinguished from the atmospheric combustion system. At the rated continuous load, air at 434 psia passes from the compressor discharge to the air heater via a heat exchanger of 87% effectiveness.

The air heater contains a number of novel features including a special suspended refractory ignition chamber this connects to a large combustion chamber and ash hopper which have been proportioned to ensure that the gas temperature at entry to the convection tube banks is sufficiently reduced to prevent build up of ash.

The combustion air preheater delivers high-temperature forced draft air to the fuel burners and to the chutes connecting the fuel feeders to the pulverizers. At present, pulverizers are arranged to discharge the dried pulverized slurry direct to the burners.



John Brown & Co. 2-MW closed-cycle gas turbine power plant. Front to rear: exciter, starting motor, generator, gear box, turbine, compressor and precooler. Air heater is on the left.

Two pulverizers are provided, one to carry one-third full load and the other two-thirds full load.

Dust collectors and fan equipment are of orthodox design with exception of the recirculating gas fan. This has been specially designed to deal with high temperature gas and fly ash.

Ignition Stability

Due to the thixotropic nature of coal slurries it is not easy to obtain a completely steady delivery of pulverized fuel at the burners when using a "direct system" of fuel firing. This problem has still to be completely solved. Also, with the simple "direct system," all water vapor released during the pulverizing and drying process passes to the burners along with the fuel. This, together with the usual high ash content of coal slurry, causes ignition delay. As a result, complete ignition stability when using coal slurry alone has not been achieved as yet and a small quantity of fuel oil has been used with the coal slurry to obtain satisfactory combustion.

Development work is proceeding to enable the plant to accept a wide range of coal slurries without use of fuel oil.

Acknowledgements

Credit is due the National Coal Board for pioneering the use of gas turbines for power generation using low grade coals and acknowledgement is due to them and to the Directors of Messrs. John Brown & Co. (Clydebank) Ltd., for permission to release this article.

Fighting Punch . . .

(Continued from page 21)

mission of unwanted noise to the surrounding sea.

For this reason alone, gas turbines will continue to be factored into minesweep and ASW ship programs as fast as practicable while also full account will be taken of their other characteristics. A current example is the 500-hp engine in our new Oceanographic Research Ship, the AGOR. Sound was isolated in the ship's stack, high above the water, to obtain the maximum noise attenuation. This unit provided creeping propulsive power and ship's service needs when extreme quiet for underwater listening is required.

Outboard-Inboard Gas-Turbine

Taking a cue from the outboard-motor industry, the Navy is again investigating quickly-replaceable outboard-type engines for personnel boats. Because of dangers associated with the gasoline required by presently-available large outboard engines, the Navy has contracted with Outboard Marine for prototype 125-hp diesel-oil-burning gas turbines for boat propulsion. These will be of the "outboard-inboard" type.

The gas-turbine engine will be mounted inside the boat, connecting through a flexible coupling at the transom to the externally mounted out-board drive assembly. This latter unit is similar to the lower portion of a normal outboard engine, and can be rotated for steering the boat. Either the engine or the outboard drive assembly can be removed and replaced in a matter of minutes, without the necessity of time-consuming alignment procedures. Both units are light and easily handled.

Cost Considerations

In the past, the gas turbine has tended to be a relatively expensive piece of equipment. As this prime mover has expanded into the industrial and marine fields, unit initial cost has been steadily reduced. As a result, there are now applications in which the gas turbine is used primarily because of its lower installed cost.

Low-Fuel-Rate Gas-Turbine Development

One major advance in the field of military non-aircraft gas turbines is the current Army-Navy development of a 600-hp low fuel-rate gas turbine. This development is a frontal attack on the two major disadvantages of present gas turbines—high purchase cost and high fuel rate. Reducing the latter should greatly broaden the application spectrum, making possible the high-quantity production required to effect really large reductions in manufacturing costs.

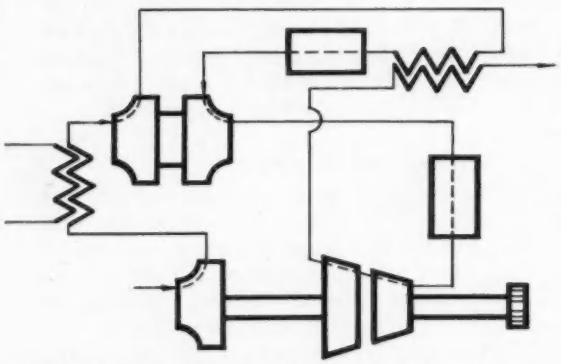
SUMMARY

In summary, the U. S. Navy is pushing forward in all fields to utilize the gas turbine wherever it is economically or militarily advantageous to do so. As more efficient and more economical marine units are developed, use of this relatively new prime mover expands accordingly.

Target: 0.4

(Continued from page 27)

Negotiations are now under way for the installation of a prototype "704" in a military vehicle. This 300-hp turbine is approximately 38-in. long, 29-in. wide and 28-in. high. It weighs 650 pounds. The 600-hp engine will be of the same turbocharged cycle as the "704" and not much larger.



Ford cycle, sometimes called the Turbocharged cycle.

Solar Aircraft Company Development

The Solar 600-hp gas turbine is expected to surpass piston engines in competitive applications. This company was awarded a contract following a design and production proposal competition among the leading manufacturers of small gas turbines.

Among the required characteristics are:

A life cycle equal to or better than conventional reciprocating engines . . . with considerably less maintenance.

Fuel consumption of 0.4-lbs/hp-hr, equal to reciprocating engines and well below current industrial gas turbine performance.

A cost competitive with conventional reciprocating engines.

This turbine is a complete axial-flow, regenerative machine with a 6-stage compressor, dual rotary regenerator, a single-can combustor, a single-stage gas-producer turbine and a single-stage power turbine. The engine will operate at a compressor pressure ratio of 3.8 and have a rotative speed of 21,500-rpm.

Editor's Note

The Department of Defense is to be congratulated for having undertaken this turbine development which, in our opinion, promises some of the most attractive gains the prime mover field has seen in recent years. The entire industry, both manufacturers and users, should profit from this important project. It is refreshing to see two branches of the Armed Forces carry out a joint development program such as this. The taxpayer's dollar is being spent in a much more economical manner than if several branches of the Defense Department were each going out and developing individual turbines.

We hope to bring you more details on the specific designs and progress of these two gas turbines as the programs develop.

Marine Propulsion

(Continued from page 26)

pressor instead of the standard 13 stages. Overall performance was not much different but the 11-stage engine proved difficult to start, particularly when hot, without use of compressor bleed. This was not required in the 13-stage design.

The first three moving compressor stages were instrumented to record vibrational stresses during the rig-testing. During early engine running, these rows were similarly instrumented. No major vibrational stresses were recorded, apart from those associated with rotating stall. These occurred at compressor speeds below 5000 rpm and the generous proportions adopted for the blading (largely for this reason) were sufficient to limit stresses to very moderate values.

Mechanical construction of the compressor rotor, with discs separated at the periphery by interstage rings, was such that a fixed-blade tip-rub automatically made itself worse due to local expansion of the rubbed (and heated) ring portion. One such rub was experienced in early testing. The short-term solution adopted was to increase compressor blading tip clearances. Some price was paid in compressor efficiency but reliability was improved. Compressor performance shown in Fig. 1 was measured on a unit having increased tip clearance.

One desirable feature of a boost naval gas turbine is its facility for rapid starting and loading. The starter motors of the G.6 are in engagement for only about 20 seconds during a normal start and full power has been achieved from a cold machine in 3½ minutes. Some temperature variations associated with rapid starting are shown in Fig. 2. This shows temperatures of cylinder casing and liners of the HP turbine during a start.

Provision is made for removing salt deposits by washing with distilled water, sprayed into the intake at about 2/3-full speed. This method has been used on previous naval machines and its efficiency is demonstrated in Fig. 3. This shows for one such machine, the power output (measured at the propeller shaft by torsion meter) at the same compressor speed over a fairly long period of operation with occasional compressor washing. Original power is restored virtually 100% after each washing.

Test results of the G.6 turbine are shown in Fig. 4. This figure is corrected to 59°F, 14.7 psia, and also to the specified full power ducting losses (0.35 psi, plus a measured silencer loss of 0.4 psi, at inlet and 0.30 psi at exhaust).

Conclusion

Development of the G.6 naval gas turbine, currently being installed in many ships of the British Royal Navy, has been described. Concept of the gas turbine as a boost propulsion machine, first tried in coastal craft, has in Britain found application in larger ships where reliability and ease of maintenance must stand comparison with the main steam turbine machinery.

The G.6 gas turbine represents a machine of 7500-shp rating that exists in a form as advanced as development on land can make it. Sea-going experience is awaited with confidence.

Jet Age Insulation Solves Locomotive Problem

Occasional exhaust stack fires in Union Pacific's locomotives handled by new insulating and silencing material

Maintenance crews responsible for Union Pacific's fleet of high-speed freight locomotives faced occasional stack fire problems. This was in the 4500-hp General Electric gas turbine locomotives. During false starts, burning fuel oil would sometimes cause a fire in the exhaust stack. The insulation material originally used would assist the fire, melting at temperatures above 1100°F.

The high temperatures caused distortion of the metal forming the outer turbine casing as well as damage to external wiring and adjacent auxiliary equipment. Result was costly repairs and out-of-service time for the locomotive.

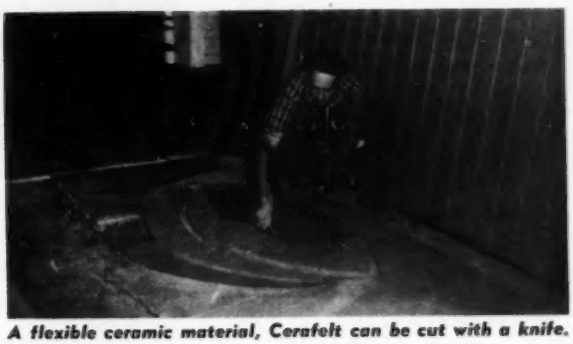
Union Pacific insisted that an insulation be used which could withstand the high temperatures if a stack fire should occur. Bullough Asbestos Supply of Salt Lake City was called in and in a joint conference with GE and the railroad's representatives, they recommended use of a high-temperature refractory felt, called Cerafelt, manufactured by Johns-Manville. This new material is a light-weight refractory-fiber insulation originally developed for use in jet aircraft.

The Union Pacific Mechanical Engineering Department, well acquainted with the excellent high-temperature characteristics and performance of Cerafelt, agreed with this recommendation and immediately authorized the General Electric Service Shop to make a test application. Shortly after, the Union Pacific specified that Cerafelt be used whenever exhaust casings were repaired.

Cerafelt, developed at the J-M Research Center, is a flexible ceramic material in felted form, suitable for continuous service at temperatures up to 2000°F—and even higher intermittent service temperatures. The material, high in alumnia and silica content, is available from J-M in various densities and thicknesses, is easily handled and can be cut with a knife. In fact, Cerafelt is in wide use as a refractory lining for original equipment and replacement oil burner combustion chambers.

Accompanying photographs show how the blanket-like refractory insulation is handled and applied to the locomotive gas turbines. It could be similarly applied to gas turbines in other service.

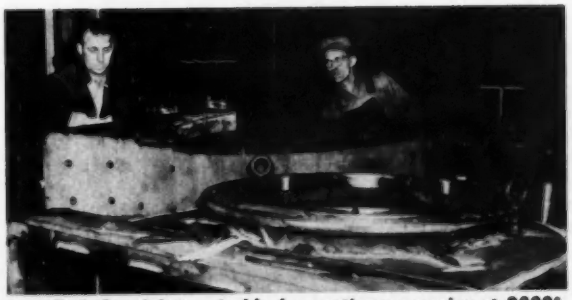
Use of Cerafelt has materially reduced maintenance of exhaust casing on these gas turbine locomotives. It was thought to be a better insulation for both heat and noise. Higher first cost of this "jet-age" insulation was quickly paid off by improved performance and reduced maintenance costs.



A flexible ceramic material, Cerafelt can be cut with a knife.

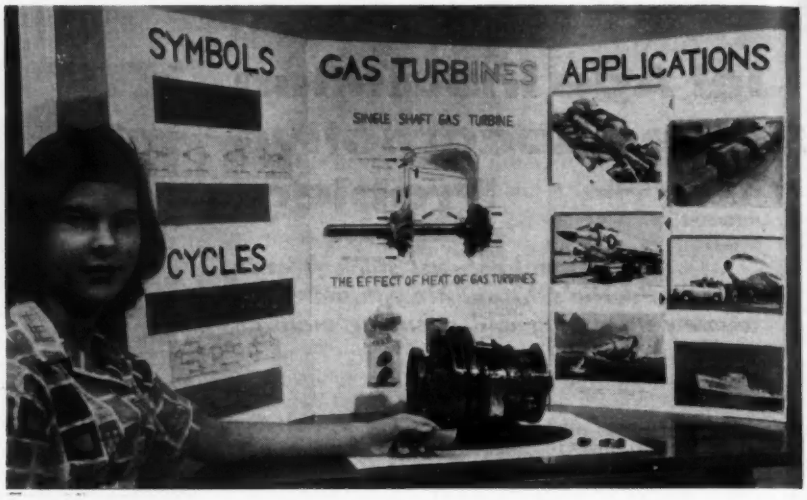
Wire mesh is fixed to Cerafelt blanket as a stiffener, to help hold in place.

For final fitting, surplus material and wire is trimmed off.



Installed, Cerafelt is suitable for continuous service at 2000°.

Schools are becoming gas turbine conscious. Not only is the gas turbine a good economic source of all power requirements for schools (see text) but children are learning about this modern prime mover in science classes. Here, Barbara Emerson, in 9th grade of Dolan Junior High, Stamford, Connecticut, shows her display for the Annual Science Fair. Gas Turbine on table was loaned by Garrett's AiResearch Div.



gas turbine system concept provides: *lighting — heating — cooling — power*

A gas turbine power plant for complete lighting, heating and air-conditioning of schools!—this was recently proposed by Mr. D. Dana Price of Goleman & Rolfe, an engineering firm in Houston, Texas, at a recent New York press conference of the American Gas Association. It was suggested that a battery of small (say 300 hp) gas turbines be used. Possibly four units would be coupled to 840-cycle generators for lighting and two units to 60-cycle generators for power supply, the exhaust from all six being used for heating and air conditioning.

Overhaul would be handled on a unit exchange basis so no major repairs would be required at the plant. This would also keep the availability factor high.

Lighting at 840 cycles is much more efficient than present 60-cycle lighting. It has also been demonstrated that it is easier on the eyes when it is the only source of light as in a room with no windows, than when mixed with day-light. Daylight is often not easy on the eyes. The point is that a modern building with no windows is extremely economical in space. It is also more economical to heat and subject to more scientific control of air conditioning than many schools with considerable glass and other openings in the outside walls.

A school of the future, similar to the above, is now being built at Beaumont, Texas. Others have already been built in Arizona and elsewhere with no windows complete with heating and controlled air-conditioning. In addition to schools, the application of a gas turbine-powered multi-service utility has also been proven in other types of buildings, shopping centers, for example. The Park Plaza Shopping Center in Little Rock, Arkansas, is illustrated as a case in point. Windows, if they existed, could do little to light or ventilate such a tremendous floor area. This would be equally true in many modern school designs.

Visitors to this impressive new $5-million shopping center may never see the giant structure's most remarkable feature. What they will enjoy without seeing is a truly remarkable feat of engineering. an *all*-gas, centrally-located power plant which takes care of all energy requirements, including lighting, heating and year-round air-conditioning.

A gas-fired turbine generates 900-kw. The high-temperature exhaust gas from the turbine is fed to a waste heat boiler, where steam is produced for heating and air-conditioning as required. This unique system is believed to be the first of its kind in operation in the U.S.

The plant's chief engineer, Homer Monasco, says the Ruston & Hornsby gas turbine generator may run for years. Actual selection of equipment and system design was made by Mr. C. L. Eldred, Assistant Chief of Operations Engineering for the Arkansas Louisiana Gas Company, in cooperation with Mr. Maury

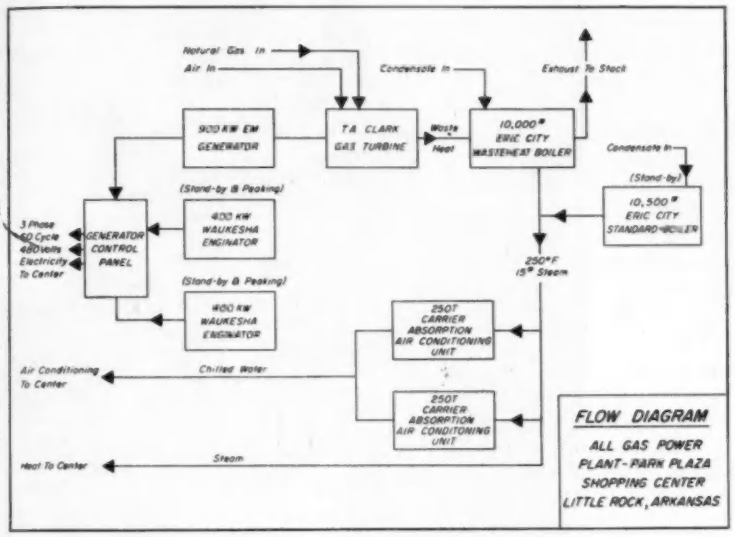
Park Plaza Shopping Center in Little Rock while under construction. Gas Turbine Power Station is 2-story building, top.

Hughes, Consulting Engineer for Lamdauer & Associates who designed the power plant building and equipment layout, and supervised construction and start-up.

Now that a gas turbine power plant can supply light, heat and air conditioning to this shopping center it can do the same for an ultra-modern school, or in fact a research laboratory, office building or any other self-contained structure.

To get back to the school situation, Mr. Price estimated considerable savings would be made, not only in operating cost but especially in first cost *while still including 840-cycle lighting and air-conditioning to an extent not found in conventional schools.*

Furthermore it was pointed out that $2,000,000,000 savings in required school taxes are foreseen by the Gas Industry during the coming decade—by installing natural gas turbines in *new-type compact schools!*



This flow diagram is specific to the shopping center, but is typical of many different systems that have been devised to provide maximum services with high overall heat utilization. The "systems" concept is growing.

Unitest governor and fuel pump test stand delivered to U. S. Navy

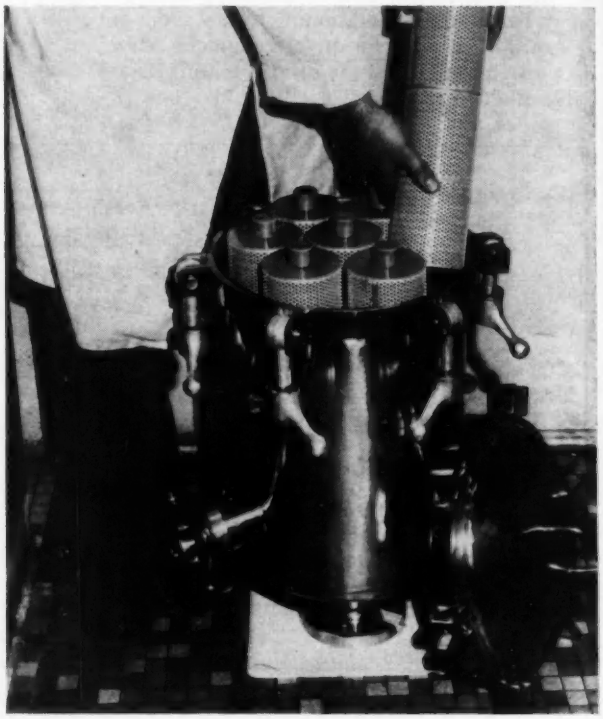
First of a new series of UNITEST gas turbine governor and fuel pump test stands has been delivered to the U.S. Navy by Marine Pumps, Inc., division of Diesel Control Corp., Wilmington, Calif. Designed to test and permit calibration of the fuel flow and controls of gas turbine pumps and governor combination, the model U-10,000 GT test stand will accommodate a wide range of units. Laboratory-accurate data is obtainable on discharge capacity, starting pressure, minimum flow, governor internal leakage, operation of relief valves, idle and high-speed control lever settings and acceleration range.

The UNITEST gas turbine governor and fuel pump test stand consists primarily of a variable-speed reversible electric drive to the unit being tested, a 3-channel Pottermeter with manual specific gravity adjustment to determine exact flow of fuel in pounds per hour, electric tachometer graduated in increments of 10 rpm, inlet and outlet pressure gauges, a fuel temperature gauge, mounting flange for governor and pump, and the necessary connecting fluid lines. The complete assembly is housed in a steel cabinet that measures 24 in. wide, 72 in. high and 62 in. in depth.

Marine Pumps, Inc. is fully experienced in design and manufacture of highly-accurate, specialized test equipment. For example, UNITEST calibration stands, flat lapping equipment and specialty tooling are widely used in diesel fuel injection manufacture and repair.

Unitest is designed to accommodate a wide range of units.

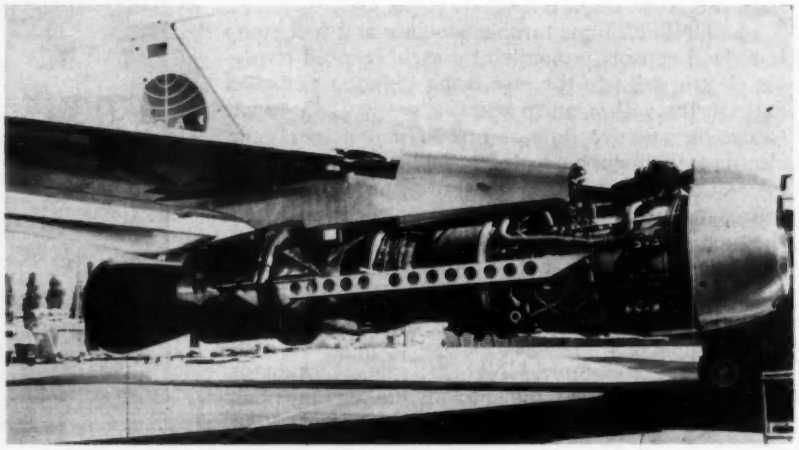
GT PRODUCT NEWS



Single-Pass High-Filtration
Every particle larger than 3 microns is removed, according to Aircraft Porous Media, Inc. Triphane (fibreglass) filters in a single pass at up to 170-gpm continuous flow of MIL-H-5606 or other petroleum-base products, and including water.
80

Portable Noise Level Meter Tester
An acoustic calibrator requiring no source of power, operating on solely mechanical means, is available from the Korfund Company, Inc. The type 1417 Acoustic Calibrator is produced by Dawe Instruments, Ltd. (London) especially for American standards. Invaluable for periodic calibration of sound level meters to insure that readings taken under different conditions are comparable. By a purely mechanical system of falling balls, type 1417 Acoustic Calibrator produces a noise which covers a frequency range centered on 1500-cps, repeatable within ±1-db.
81

Ground Jet-Noise Suppressor
Universal type "UDAC" ground jet noise suppressor built by Industrial Acoustics Co. was developed exclusively for use with commercial jet transports such as the Boeing 707 and Douglas DC-8. "UDAC" unit, shown mounted on the rear of the jet engine, allows the plane to move around on the ground to obtain suitable location for ground jet run up and testing.
82



New Micron Filter

Pacific Sintered Metals Co., filter is claimed to remove contaminants to 5 microns from all liquids and gases. The PORO-PAC features corrosion resistant brass cases; porous metal sintered bronze, ductile shock-proof elements that are easily cleaned and require no replacement; and operating temperatures of −400°F. to +900°F.

83

Auxiliary Power

Designed for operation only at −25°F. or below, three AiResearch small gas turbines are currently undergoing evaluation cold testing on new Chrysler built M-60 Army medium tanks. The turbines in use are GTCP 30 combination compressor-shaft power models built by The Garrett Corporation's AiResearch Manufacturing Division, Phoenix, Arizona. The turbine weighs only about 45 pounds.

84

Olympia Show

English Electric will be exhibiting, April 20-May 4, their EM27P industrial unit, one of three ordered by the Assam Oil Company for the Nahorkatiya power station to supply power for the oil refinery. Two sets, to run on natural gas, are now erected. The EM27 is designed to operate on distillate fuels, natural gas or crude oil. It is a compact, open-cycle, two-shaft unit, readily transportable and easy to install for many industrial, traction and marine applications.

85

Brazing Cuts Weight and Cost

A unique redesign that utilizes inherent advantages of the brazing process has cut weight while reducing overall cost 35% in an aircraft valve body asembly. The part is now assembled from two castings and two threaded bosses. The bosses are produced on a screw machine. All components are made from 17-4 PH stainless steel.

Previously, the valve body had been produced as a one-piece 17-4 PH casting. Engineers at Stainless Processing Division of Wall Colmonoy Corporation, Detroit, producer of the new brazed assembly, redesigned the part to take maximum advantage of furnace brazing process techniques.

86

Standardization by Delavan

A standard low cost Dual Orifice nozzle (Patent No. 2703260) for gas turbine engines has been developed by Delavan Manufacturing Company, West Des Moines, Iowa.

This nozzle fulfills an industry need for inexpensive fuel atomizers, readily available for quick engine tests or for small quantity orders where special designs are not warranted. Basic parts, installation dimensions and materials are standard. Reasonable departures from these standards are available to allow for special flow rates or spray angles. All parts are manufactured from corrosion resistant stainless steel except for one aluminum seal.

87

"Custom-Built" Mufflers Curb Industrial Noise

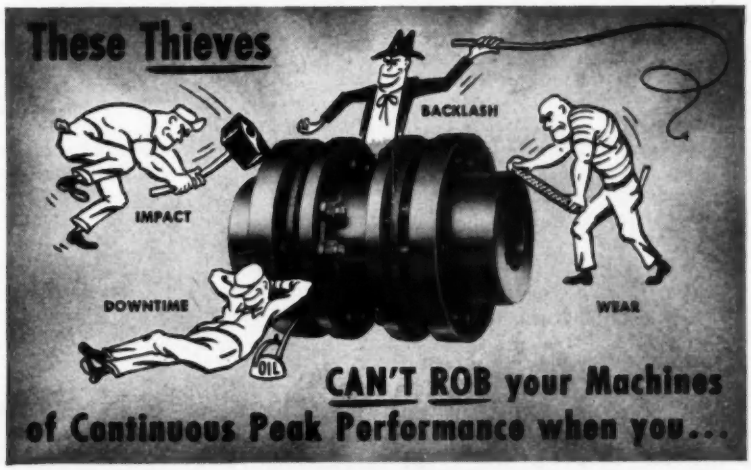
To meet the growing demand for noise silencing devices, Industrial Acoustics Company, Inc., a leading company in the field, has standardized on 5 complete lines of mufflers. Each series of the standard mufflers are assigned to curb noise of specific types of installations, for example:

The "C.F. Series" is a heavy duty industrial muffler for medium and low velocity discharges and are applicable for the discharge of air, gas and steam relief valves, intake of turbo super-charged diesel engines, and gas turbine inlets and exhausts.

The "S.T. Series" are straight through mufflers designed for the reduction of high frequency noise, generated by the intake and discharge of centrifugal type fans, blowers and compressors.

88

Use your GT Reader Service Card.



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High degree of accuracy, reliability and performance make Thomas Flexible Couplings the worlds best.

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WARREN, PENNSYLVANIA, U.S.A.

For more information write in No. 72

GT PATENTS

By J. W. Sawyer

HEAT EXCHANGERS (2,965,361) 2 CLAIMS Frank L. Schwartz, Ann Arbor, Mich., assignor to Continental Aviation and Engineering Corporation, Detroit, Mich. Relates to a control and sealing means for effecting minimum leakage losses in a rotary type heat exchanger.

COMPRESSOR INSPECTION PORT (2,965,286) 8 CLAIMS Walter A. Ledwith, Glastonbury, and John C. Carr, Unionville, Conn., assignors to United Aircraft Corporation, East Hartford, Conn. One feature of the invention is the provision for inspection ports in the casing of the compressor to permit insertion of tools for inspecting the blades.

COMPRESSOR BLEED CONTROL (2,965,285) 13 CLAIMS Carl F. Schorn, Detroit, Leonard W. Keil, Birmingham, and James A. McGrail and Philip M. Rogers, Royal Oak, Mich., assignors to Holley Carburetor Company, Detroit, Mich. An automatic, efficient and practical mechanical device that will continuously sense speed of the low speed compressor, compressor inlet air pressure, compressor inlet air temperature and combine the effects into a signal which will open or close a compressor bleed valve at any desired speed, pressure or temperature.

JET ENGINE EXHAUST SOUND SUPPRESSOR AND THRUST REVERSER (2,968,150) 8 CLAIMS Kenneth W. Goebel, San Diego, and Lanvin G. Pierce, National City, Calif., assignors to Rohr Aircraft Corporation, Chula Vista, Calif.

VANADIUM-CONTAINING RESIDUAL FUELS MODIFIED WITH ZINC AND ALKALI METAL COMPOUNDS (2,968,148) 6 CLAIMS Albert G. Rocchine, Oakmont, and Charles E. Trautman, Cheswick, Pa., assignors to Gulf Research & Development Company, Pittsburgh, Pa.

ROTATING HEAT EXCHANGER (2,963,278) 13 CLAIMS Johannes Gassmann, Altbach, near Esslingen, and Horst Witt, Stuttgart, Germany, assignors to Daimler-Benz Aktiengesellschaft, Stuttgart, Germany. Heat exchanger which automatically prevents dirt or other foreign particles from collecting at the disks to avoid reduction of the capacity to transfer or exchange heat.

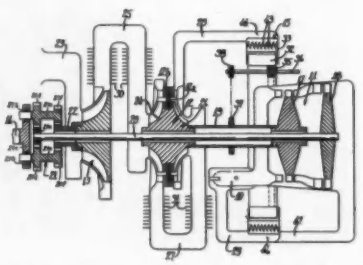
ACCELERATION RATE CONTROL FOR GAS TURBINES (2,968,151) 10 CLAIMS Frank J. Abraham, John R. Anderson, and Robert W. Teel, Seattle, Wash., assignors to Boeing Airplane Company, Seattle, Wash.

SPEED AND TEMPERATURE RESPONSIVE FUEL CONTROL SYSTEM FOR COMBUSTION ENGINES (2,959,920) 17 CLAIMS William E. Brandau, Westwood, N. J., assignor to The Bendix Corporation.

INTERNAL COMBUSTION ENGINES (2,959,918) 17 CLAIMS Harold Edward William West, Allestree, England, assignor to Rolls-Royce Limited, Derby, England.

SYSTEM FOR PREVENTING RECIRCULATION IN CLUSTERED TURBINE ENGINES (2,960,821) 5 CLAIMS Ely Scherl, Wakefield, Mass., assignor to General Electric Company.

REEXPANSION GAS TURBINE WITH DIFFERENTIAL COMPRESSOR DRIVE (2,960,825) 4 CLAIMS Archilles C. Sampietro, Ann Arbor, and John P. Heiss, Flint, Mich., assignors to Thompson Ramo Wooldridge Inc. The reexpansion gas turbine, with differential compressor drive, incorporates regeneration and intercooling which is accomplished through a refrigeration system utilizing heat in the exhaust gas after it leaves the regenerator. Air enters the inlet 23 and then is compressed in compressor 13. Then to the second stage compressor 24 and final compression takes place in compressor 26. Air is intercooled



after the first and second stages by heat exchangers 30 and 31. After the third stage air enters heat exchanger 15 and is preheated before entering combustion chamber 10. Products of combustion first enter high pressure turbine 17 which connects to multi-stage compressor 12 through hollow shaft 19 to form a free spool compressor-turbine assembly. Gases then enter turbine 18 which is differentially connected to the single stage compressor 13 through a turbine shaft 20, an epicyclic gear train 21 and output shaft 14.

SLOTTED VANE TURBINE GOVERNOR (2,962,258) 8 CLAIMS William A. Wagner, Sepulveda, Calif., assignor to The Marquardt Corporation.

TURBINE OVERSPEED CONTROLS (2,962,257) 14 CLAIMS William D. Allingham, Seattle, Wash., assignor to Boeing Airplane Company Seattle, Wash. Control device takes the form of a ring of ductile metal, connected to the rotor, which has a yield speed sufficiently high to maintain the ductile ring in its normal shape and disposition throughout the normal speed range. Its yield speed is sufficiently lower than the yield speed of the remainder of the rotor assembly that the ductile ring will yield plastically radially outward under influence of centrifugal force prior to the yielding of the rotor, upon reaching a speed in excess of a predetermined limit. The ductile ring may yield radially and come in contact with the inner surface of the annular housing, this causing a rub which results in a braking action.

STARTING APPARATUS FOR GAS TURBINES (2,962,859) 22 CLAIMS John Donald Hodgson, Edgware, and George Dobson, London, England, assignors to The De Havilland Engine Company Limited, Leavesden, Hertfordshire, England.

HEAT EXCHANGER (2,963,279) 6 CLAIMS John C. Vickland, Wellsville, N. Y., assignor to The Air Preheater Corporation, New York, N. Y. Regenerative air preheater in which a body of heat exchange material is first traversed by a heating gas and then by another fluid such as air to which the heat is imparted.

TURBINE (2,960,306) 5 CLAIMS John S. Collman, Detroit and James M. Ricketts, Oxford, Mich., Assignors to General Motors Corporation, Detroit, Mich. Turbine and stator constructed of loose parts which may be fitted together and interlocked so that they may expand and contract relative to each other so as to prevent development of harmful thermal stresses.

DIFFUSER (2,967,013) 4 CLAIMS Frederick Dallenbach, Phoenix, Ariz., Hans P. Eichenberger, Cleveland, Ohio, Eugene M. Knoernschild, Los Angeles, Calif., and Nguyen Van Le, Phoenix, Ariz; said Dallenbach assignor to The Garrett Corporation, Los Angeles, Calif. A vaned diffuser which will operate efficiently when flow decelerates from supersonic to subsonic velocities without the formation of compression shock waves.

GT PRODUCT TECHNICAL FILE

Spiral-Wound Gasket Catalog Set

Flexitallic Gasket Co. has prepared a beautifully-done and complete cataloging of their spiral-wound gaskets line. Includes asbestos gaskets and a special section on Teflon. In addition, many schematic drawings of general interest to mechanical people are included. These are sections of gasket applications, which will be of assistance to anyone who ever finds it necessary to join flanges or create a seal of any kind. This beautiful catalog set is free for the asking.

89

Bendix Corporation

New pamphlets are available from this corporation describing fuel control from the Products Division.

Brushless AC generating systems and starter generator bulletins are available from the Red Bank Division.

The Eclipse Machine Division has a new bulletin on fuel nozzles for gas turbines.

All of the above divisions are producing equipment for practically all applications the gas turbine can be used in, for example note Bendix control on the Chrysler automotive turbine.

90

Allison Power

Two pamphlets have been issued, one describing the Allison T63, the aircraft version of Allison's turbine. The other pamphlet describes the industrial unit known as model 250. Both units are rated 250-hp. The complete weight of either unit is in the neighborhood of 100 pounds, depending upon its specific application. Both are equipped with a separate power turbine, no heat exchanger is used on these units in order to obtain a minimum unit weight.

91

GE Model 240

This 24-page brochure illustrates how the Evendale plant of the General Electric Company is now in a position to produce a turbine for marine and industrial applications with a rating of up to 20,000-hp. Here a jet unit has been redesigned for industrial service and yet retains its original high efficiency. Complete figures and other data is included.

92

Creative Test Engineering

This brochure distributed by Aerotest Laboratories shows their extensive facilities for both standard and creative testing. This company is in a position to not only test gas turbine component parts but the complete gas turbine. Their laboratory is well equipped for this purpose as shown by the brochure.

93

Orenda Products for Power

Two well illustrated brochures describe the Orenda line of industrial gas turbines available. One describes the OT-2 and OT-3 turbines, the OT-2 is rated 6200-hp with heat exchanger and 6700-hp without heat exchanger. The OT-3 is only without heat exchanger, being a more compact design than the OT-2 yet rated 6700-hp. Both will handle up to 12,000-hp on a cold day.

The OT-5 unit is rated 1500-hp with heat exchanger and 1615-hp without. In a cold day it can handle up to 2885-hp.

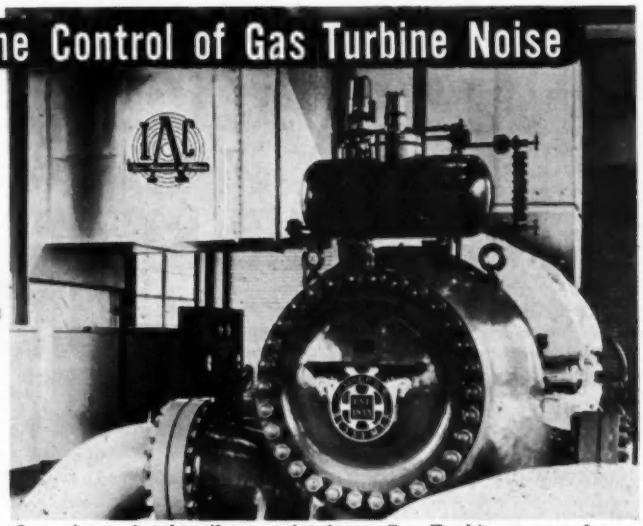
94

New Power Concept

Cooper-Bessemer's 8-page bulletin on the above subject describes their RT-248 gas line pumping unit. Illustrations, charts and data show the many advantages claimed for this type of gas turbine power plant.

95

For the Control of Gas Turbine Noise



One of two intake silencers for large Gas Turbine powered compressor in a gas pipe line transmission facility.

IAC Intake and Exhaust Silencers have solved special noise problems in hundreds of installations. Our Engineering Department will gladly work with you in solving your noise problems.

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IAC Mufflers are available in five series for Low to High (up to and including Sonic-Flow) velocities. Ask for Bulletin #MUF-218.

For more information write in No. 73

GT TECHNICAL BRIEFS

Papers Presented at Sixth Annual Gas Turbine Conference and Products Show, Shoreham Hotel, Washington, D. C., March 5-9, 1961. Jointly sponsored by Gas Turbine Power Division of ASME and Department of Defense.

A Gas Turbine "CO" Boiler Installation: Economic and Thermodynamic Analysis, by C. Bultzo, Senior Mechanical Engineer, Humble Oil and Refining Company, Baytown, Texas (No. 61-GTP-1).

The Coal Burning Closed Cycle Gas Turbine by Curt Keller, Dr., Director of R & D and W. Gaehler, Chief Engineer, Gas Turbine Division, Escher Wyss, Ltd., Zurich, Switzerland (No. 61-GTP-2).

Use of Experimental Interstate Performance Data to Obtain Optimum Performance of Multistage Axial Compressors by Laurence E. Brown and Fred G. Groh, Research Division, Curtiss-Wright Corporation, Quehanna, Pa. (No. 61-GTP-3).

Standby Power for Hydro-Quebec Uses Gas Turbines by H. W. Haberl Assistant Chief Engineer, Engineering Design Division, Quebec Hydro Electric Commission, Montreal, Quebec, Canada, and D. F. Abel, Specialist—Turbine Sales, Canadian General Electric Company, Limited, Peterborough, Ontario, Canada (No. 61-GTP-4).

A 7,500-S.H.P. Gas Turbine for Naval Boost Propulsion, by F. R. Harris, Chief Engineer, Gas Turbine Department, Turbine-Generator Division, Associated Electrical Industries, Manchester, England (No. 61-GTP-5).

The Orlando Gas Turbines by C. H. Stanton, Secretary and General Manager and H. C. Luff, Manager, Electric Generation, Orlando Utilities Commission, Orlando, Fla., (No. 61-GTP-6).

Two simple-cycle gas turbines, in a power plant, cost $110 per kw of installed capacity. Now, with their first 1500-hr of fired time on record, we have a report on their performance in service.

Design and Development Review of the T64 Turboprop/Turboshaft Engine by Frederick F. Ehrich, T64 Engine Design Engineer, Small Aircraft Engine Department, General Electric Company, West Lynn, Mass. (No. 61-GTP-7).

Operation of 8500-hp Gas Turbines in Locomotive Service by H. Rees, Union Pacific Railroad Company, Omaha, Nebraska (No. 61-GTP-8).

These locomotives have accumulated over 95,000 fired hr since the first locomotive was placed in main-line duty September 1958. Nineteen locomotives are now operating; 11 more will be delivered by July 1961.

Segregated Structures in Highly Alloyed Ferritic Gas-Turbine Wheel Forgings by G. R. Heckman and A. W. Herbenar, Gas Turbine Department, General Electric Company, Schenectady, N. Y. (No. 61-GTP-9).

Sea Power: Gas Turbines Add More Fighting Punch, by R. K. James, Rear Admiral, Chief, Bureau of Ships, Navy Department, Washington, D. C. (No. 61-GTP-10).

Practical Realization of Gas Turbines Combined With Steam and Industrial Heat Cycles by Werner P. Auer, Chief Engineer, Gas Turbine Sales and Application Engineering Department, Brown Boveri and Company Limited, Baden, Switzerland (No. 61-GTP-11).

Design Consideration and Operating Experience of Regenerators for Industrial Gas Turbine, by R. F. Caughill, Assistant Chief Engineer, Harrison Radiator Division, GMC, Lockport, N. Y. (No. 61-GTP-12).

Transient Temperatures and Thermal Stress Problems in Small Gas Turbines by Robert R. Van Nimwegen, AiResearch Manufacturing Company of Arizona, a Division of The Garrett Corporation, Phoenix, Ariz. (No. 61-GTP-13).

Technical Considerations in the Development of a Maritime Gas-Cooled Reactor System (AEC Contract AT(04-3)-187), by Bernard T. Resnick, Chief, Marine Engineering Research Branch, Office of Research and Development, Maritime Administration, Washington, D. C. (No. 61-GTP-14).

The Maritime gas-cooled-reactor concept is a closed-cycle nuclear propulsion system in the 20,000-shp range. The power cycle consists of a beryllium-oxide, helium-cooled reactor, directly coupled to a closed-cycle axial-flow, split turbine. The current status of turbomachinery and reactor technology are discussed.

Materials Keep Pace With Industrial Gas-Turbine Needs, by Harry B. Gayley, Industrial Gas Turbine Department, Steam Division, Westinghouse Electric Corp., Philadelphia, Pa. (No. 61-GTP-15).

Reliability and improvements in industrial gas turbines are closely related to the materials study programs which are conducted in support of the turbine design. The studies at the author's company are described with presentation of blade and disk material data. Field experience as related to materials evaluations are described, with particular emphasis on returning parts to service. Materials now available when fully evaluated through the program described, will permit metal temperatures 100°F higher than currently used.

Conclusion of Paper.

The materials which are currently available, W545 disks, and Inco 713-C blades coupled with cooling provide a means of enhancing the growth potential of industrial gas turbines by increased power output, and efficiency. Development programs and service experience programs are under way to provide these improvements with materials at current factors of safety.

Operation of the Heat Transfer Reactor Experiment No. 3 (HTRE 3), (in which two turbojet engines were powered by a single nuclear reactor) by Ben Blumberg, Jr., of the General Electric Aircraft Nuclear Department (ANPD), Cincinnati, Ohio, (American Nuclear Society Meeting, Dallas, Texas, March 28-29, 1961).

Author states that a ground test program completed this year, "has proved that the system operated essentially as predicted with the most sophisticated gas-cooled reactor design that has operated to date. With the application of this experience, a much greater degree of confidence and objectivity will characterize future designs."

The following papers were presented at the 1961 SAE National Aeronautic Meeting in New York City, April, 4-7.

New Types and Applications of Turbine Engines for Short and Vertical Take-Off by John M. Stephenson, Lycoming division of Avco Corporation, Stratford, Conn., (No. 337B).

Evaluation of Army's VTOL Test Beds by John Beebe, TAFO Office, Dept. of Army (No. 337C).

Turbine Powered Transport Aircraft in the USSR by Donald J. Ritchie, Research Laboratories Div., The Bendix Corp. (No. 345A).

Marine and Industrial Uses of the Proteus and Olympus Engines by B. H. Slatter, Bristol Siddeley Engines, Ltd. (No. 347A).

Industrial Power Requirements and the Aircraft Gas Turbine Engine by W. J. Closs, Pratt & Whitney Aircraft, Division of United Aircraft Corp. (No. 347B).

One Pound/Horsepower—New Weight Standard for Ground Power by Kenneth A. Austin, Lycoming Division, AVCO Corporation (No. 347C).

Characteristics of the U.S. Maritime Administration Hydrofoil Test Vehicle by Glen J. Wennagel, Dynamic Development Inc. (No. 355C).

(More on page 42)

High Temperature Metals

This is the name of a 52-page brochure issued by Universal-Cyclops Steel Corporation. This is well illustrated with many charts, diagrams and tables giving the details on over 16 separate metals, many of which are of benefit to gas turbine designers. **96**

Gas Turbine Engines

This is the name of a circular distributed by Williams Research Corporation illustrating turbines they are manufacturing for aircraft, industry, marine and the automotive fields. **97**

HY-VO Chain

"Modern Chain for Modern Power". According to Morse Chain Company this chain is the only available for high speed gas turbine work. A new circular describes this chain, shows its construction and the many gas turbine and other aplications it is now used on. **98**

Woodward Controls

Bulletins covering small gas turbine fuel controls and also gas turbine governing are available from the Woodward Governor Company. **99**

Proteus Turbo Generator

This well illustrated publication shows how Bristol Siddeley brought automation to the industrial power supply with their 3MW gas turbine set. **100**

Blast-Furnace Gas Turbine

Sulzer Brothers of Switzerland have a circular describing their 8,000-kw unit for blast-furnace service. **101**

Alloy "713C"

A pamphlet describing the machining and grinding of investment carting alloy "713C" is now available from the International Nickel Company. **102**

Utica

A brief pamphlet lists the many types of blades and buckets the Utica Drop Forge and Tool Division manufacture for gas turbines. **103**

Harrison Heat Exchangers

A new 48-page brochure describes Harrison heat exchangers, many of which are specifically used on gas turbines ranging from a few hundred horsepower up to many thousands of horsepower. This pamphlet is extremely well illustrated. **104**

New Dimension in Peaking

This handsome brochure distributed by Westinghouse Electric Corporation gives a detailed description as to why Westinghouse gas turbine generators should be used for peaking purposes. **105**

Gas Turbine Systems by Garrett

New 12-page brochure describes Model GTCP85-91 which provides shaft horsepower and compressed air power simultaneously, or either form of power independently and interchangeably. It is used for a wide variety of ground and airborne applications. **106**

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Technical Briefs. . .

(Continued from page 41)

"The Generation of Electricity by Wind Power" by E. W. Golding, book published 1955 by E. & F. N. Spon Ltd., London, England (50S)

For an unusual gas turbine design see Plate XXVII. In the 100-ft high steel base of the airtight wind mill, is located the power turbine driving a 100-kw generator at St. Albans, England. Atmospheric pressure drives the turbine as the air is pulled up by suction to the center of the 80-ft diameter hollow blades of the mill and thrown out the tip by centrifugal force. This is known as the Enfield-Andreau machine. Scientists around the world are still experimenting with wind power and in a few cases the gas (or expansion)) turbine is being used.

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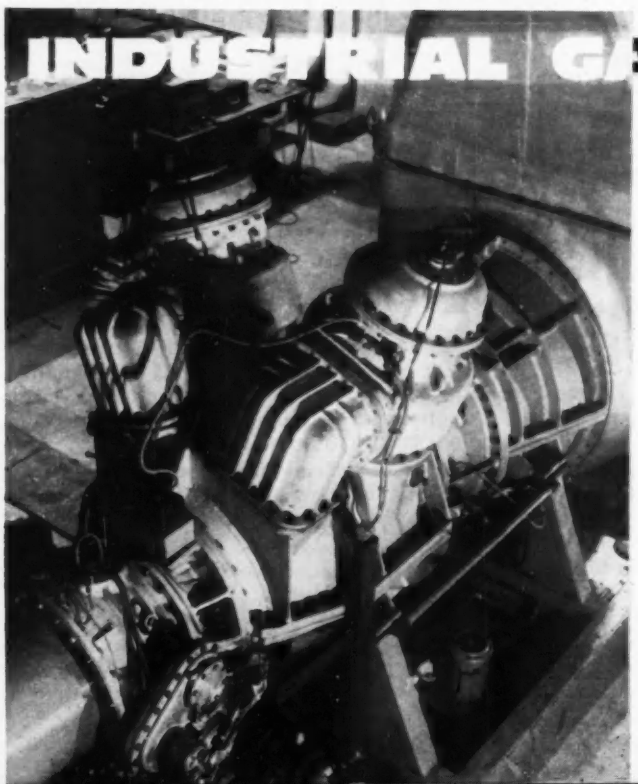

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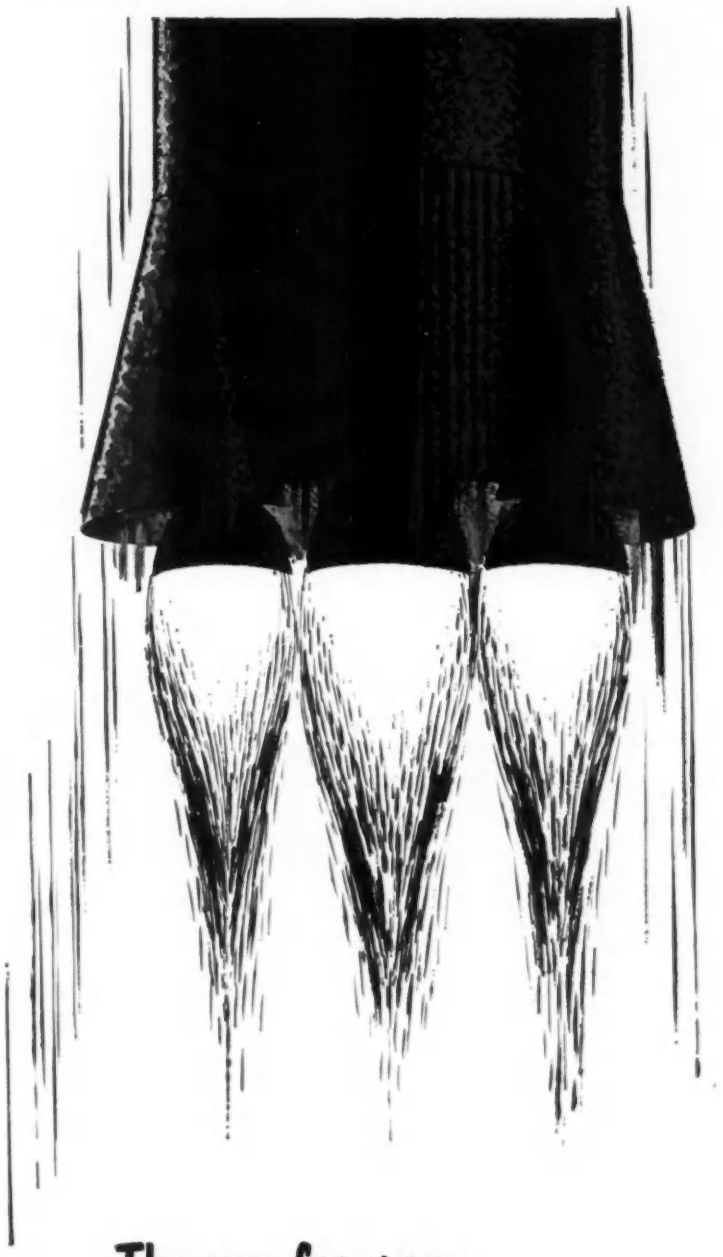

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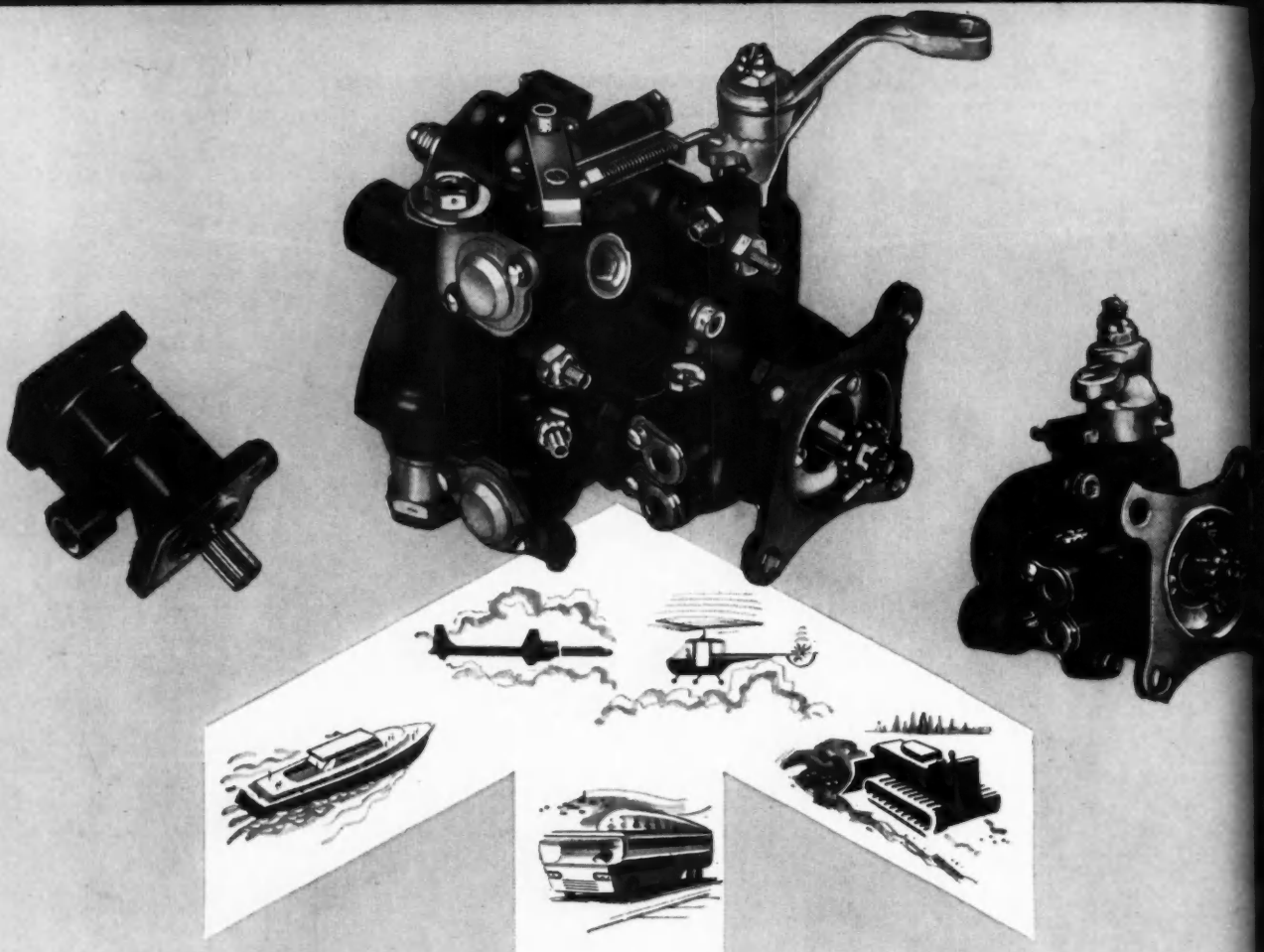

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